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A STUDY IN SOCIAL DYNAMICS: A STATISTICAL DETERMINATION OF THE RATE OF NATURAL INCREASE, AND OF THE FACTORS ACCOUNTING FOR THE INCREASE OF POPULATION IN THE UNITED STATES.

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Little appears to have been published relative to the specific points discussed in this study. The present writer has become interested in the field in consequence of the repeated attempts he has made to ascertain the amount of rural migration. In seeking to devise methods by which that factor could be measured, he has gradually developed conceptions as to how the larger problems of natural increase for the nation and its parts and how the factors which determine any particular kind of community increase may be measured. His earlier publications of estimates of rural migration unfortunately were inaccurate, but a later study* in this present field, which embraced a calculation of that factor also, laid a more ample and trustworthy foundation for the present investigation. In the same issue Mr. Earl Clark, of the Russell Sage Foundation, published an estimate of the factors of urban increase in the United States,† the results of which, when account is taken of the somewhat different view of the scope of the undertaking, practically agree with those embodied in the study just cited.

Investigations relative to natural increase of population in

*"Measure of Rural Migration and Other Factors of Urban Increase in the United States," by John M. Gillette and George R. Davies, Quarterly Publications of the American Statistical Association, Vol. XIV, pp. 640-653.

†"Contributions to Urban Growth," by Earl Clark, *Ibid*, pp. 654-671.

the nation as a whole, in its several geographical divisions, and in its distinct types of communities, rural and urban, which further attempt to analyze the situation relative to those different areas and communities so as to exhibit the comparative strength of the various determining and contributing factors affecting the increase or decrease, are of the profoundest significance. They are far beyond being of "academic" interest only, for they reveal the mechanism of the national population at work and the basis for a causal interpretation in the field of economics, political science, sociology, history, ethics, and other related sciences. They throw light on and go far towards answering the question as to what stocks in our population, native or foreign born, are the vigorously reproductive ones. They yield data which will do much to determine whether or not immigration to this country has actually increased the population beyond what it would have been had the nation depended on its own reproductive powers alone. They also help to answer the query as to which kind of community, rural or urban, is the more advantageous with respect to the increase of population. In like manner they reflect the determinative influence which economic opportunities have on natural increase as exhibited in the varying rates of the different geographical divisions. Further, these results reveal unmistakable differences between native and foreign stocks, and the Negro and white races, in their competition for survival.

Such considerations and results invest the data with a practical concern of the utmost gravity. They project into the governmental sphere such questions as these: what stock, regions, and kind of community are most advantageous when measured by their effects on the fecundity of population? Since the results are what they are, what should the governments, national, state, and municipal, undertake to ward off the decadent tendencies and to place a premium on the beneficial ones?

They also project the same practical questions into the arena of individual consideration, and arouse serious personal concern. In view of the unfavorable conditions that must be inferred to exist in some regions or in some kinds of community,

should he seek to cast his lot in the region or community which is proven to be the more favorable to human life? The vast interdivisional migration of native born populations indicates that already millions of people are instinct with this consideration. Should other millions once become intelligent and acquainted with the actual conditions, a movement might result that would change the balance of population and affect the destiny of great areas.

The difficulties involved in making estimates in this field are great. Because of the almost overwhelming complexity of the situation, the multitudes of unknown factors involved, and the dearth of exact and pertinent data, the project is not dissimilar to that of the celestial physicist who, not being able to observe the disturbing body, is obliged to locate it by a long series of mathematical calculations.

The veteran statistician knows perfectly well that an investigation of this nature develops problem after problem for which there exists no ready made solution and which the ingenuity of the investigator must meet by devices and methods wrought out as occasion demands. The search for facts which will give a cue to the solution of such problems is time-consuming and frequently disappointing. Circuitous methods are often necessary which many times lead the zealous amateur worker into blind alleys. It may be glorious to spend a month of earnest effort to work out results by a newly invented device, but if they are worthless it is indeed discouraging. There is no glory unless success is at last attained. The writer has nearly 200 pages of legal notepaper filled with the mere indication of methods and results developed in the course of this investigation, and the mathematical operations to carry out the methods would demand a far greater space. It has often been a case of trial and error. Perhaps the reason the task has not been executed earlier was that the veteran statistician suspected the risks involved in the project and the foolhardiness of the undertaking.

The statistician does not expect absolute accuracy in a set of statistical results because he knows that statistics is the science of estimates and that the final figures are only approximations. The only claim that a statistical in-

vestigator dare make is that his conclusions come close to the true situation.

The writer has sought to work out scientific methods by means of which the problems set up might be solved. That there is such close conformity in several sets of results which were worked out by utterly different methods is the most convincing evidence to his mind that the conclusions are approximately correct. This is particularly true respecting the rates of natural increase attained for the United States. Those worked out by means of data and methods quite independent of each other show a divergence of only about five one hundredths of one per cent. And much the same is true of the division rates independently obtained, and of the totals of the factor, rural migration, resulting from several distinct operations.

I made certain modifications in mortality rates, as a concession to Professor Walter F. Willcox, after I read his strictures on low mortality rates reported by some of our western states.* I revised my estimates in several states for both rural and urban districts, raising them somewhat above my first estimate. Since the rates for these communities, for the different divisions, and for the nation are the weighted averages of the local rates, the final rate of natural increase for the nation was only slightly lowered.

No doubt the general scheme adopted here will undergo a modification in certain of its particulars in the hands of critical investigators. But the present undertaking should serve as a foundation and point of departure for future workers in the attainment of similar results. When the next census data are made available, it will be possible to apply the plan developed here to these data and to secure results with a minimum cost in time and labor.

By natural increase is meant, for the purposes of this paper, the increase that was made during the decade 1900–1910 by the population of 1900, independent of the gains from immigration. Since my chief aim is to reckon the potency of our various population areas and communities, the factor of emigration must be considered, since to disregard it would be to

* Quarterly Publications of the American Statistical Association, Vol. XIV, pp. 711–726.

distort the idea of our real producing ability. This conception of natural increase differs from the one commonly employed, since the latter includes all actual gains by natural increase to the initial population, whether due to its own reproductive processes or to those of immigration.

A considerable degree of positivity attaches to the rate of natural increase estimated for the nation because that rate has been established by two different methods. The first method consists in the use of immigration and emigration to determine what part of the decennial growth of population was due to natural increase and what was the potency of the latter. The second method seeks to establish birth and death rates for the nation, the difference between the birth rate and the death rate being the rate of natural increase. It will be seen that two different estimates of the birth rate are employed and that these are variants of the second method.

The national population in 1900 was 75,994,575; in 1910 it was 91,972,266, a gain of 15,977,691.* This increase of 21.0 per cent. can not be the rate of natural increase of the nation because of the disturbing factors of immigration and emigration.

The factor of emigration necessarily enters into the process of estimating the rate of natural increase of the nation, when the determination of that increase involves the computation of the relative force of the various causes which produce gains and losses in the population. Emigration counts as a loss factor, but nevertheless it is a positive element in calculating the potency of natural increase.

Strange as it may seem our national government has done practically nothing toward recording losses of our permanent population. It keeps a record of emigrant aliens, but statistics which could form a basis of judgment as to the amount of emigration of citizens are scanty and only within the last few years have these data appeared. Consequently my first attempt at estimating the force of this factor was based on the statements of emigration from the United States to Canada published by the Canadian government. The results of the estimate appeared in a recent article in the Publications of the

*Abstract of 13th Census, p. 22.

American Statistical Association.* It was reckoned that during the decade 1900–1910, 517,000 individuals settled in Canada† and that enough more went to other parts of the world to bring the total emigration up to 550,000. The present calculations indicate that this amount is approximately correct.

The more recent reports of the United States Commissioner General of Immigration‡ afford data from which an approximation can be made. They record the number of citizens of the United States annually arriving and departing at ports of entry and at the Canadian boundary stations. During the four years, 1911–1914, the excess of departures over arrivals was 296,742. For a ten year period at the same rate, the excess would total 741,830. Assuming that the same relative emigration occurred during the preceding decade, and proportioning the excess to the average population of that decade, the resulting emigration for 1900–1910 is found to be 557,000. This so nearly corresponds to my previous estimate that that estimate may be used unchanged.

We may anticipate the rate of natural increase in the nation to apply to this amount of emigration for finding its total reducing power on our population. Had the 550,000 persons remained in the United States their number would have been increased by one half of 13.7 per cent. making the total loss 588,000.

Since 1820 immigration has been an increasing factor in the growth of our population. The United States has exhibited the most rapid rise in population of all the modern nations, Russia standing as a close second. It is a matter of great importance to determine to what degree our national population of itself contributes to this remarkable advance. How far will immigration account for the decennial rate of gain of 21 per cent.?

In estimating the contribution of immigration, since I am determining the potency of the 1900 population, it will be necessary to reckon the decennial net immigration, and the

*Sept., 1915, p. 645.

†"Immigration Facts and Figures," issued by the Minister of the Interior, Ottawa, Canada, p. 3, gives data for the Canadian estimate.

‡Reports of the Commissioner General of Immigration, United States, 1912, p. 67, and 1914, p. 35.

natural increase for that immigrant population. The first task is simple, the other one difficult because of great complications.

The United States Bureau of Census estimates the net immigration of the decade, 1900–1910, as 5,250,000.* This closely agrees with the results obtained by reckoning that 80 per cent. of the foreign born within the United States in 1900 lived in the United States in 1910† and subtracting the amount from the number of foreign born enumerated in 1910. This gives a net immigration of approximately 5,243,000.

It is necessary to discover how much this net immigration is incremented by its own natural increase during the decade in question. My estimate of 17.4 per cent. as the rate of natural increase for that population was obtained as follows:

The birth rate for immigrants was reckoned by taking the European birth rates of Hungary, Prussia, Germany, Italy, Great Britain, Norway, Sweden and Denmark, France, Spain, Portugal, and Ireland, nations from which we obtain the bulk of our foreign population, and weighting them by the appropriate populations living in the United States. This was found to be 32.8 in 1900.‡ Had we the figures for Russia, the average rate doubtless would be greater.

This average rate of 32.8 must be increased because of the excessive adultness of immigrants. As compared with the population of the United States in 1910, the immigrants of the decade ending 1910 were 59 per cent. more adult, that is, were of the fecund age, 15 to 45, to an extent 59 per cent. greater than the whole population.§ So increased, the birth rate becomes 52.2.

But immigrants have a preponderating maleness. I estimate that females constitute 38.6 per cent. of the net immigrant population.‖ Assuming a male for each female, there is an excess of 22.8 per cent. of males over females. The last resulting rate, reduced by this percentage, is 40.5. It is pos-

*Abstract 13th Census, p. 191.

†Census 1910, Polulation, Vol. I, p. 1017.

‡Abstract 13th Census, p. 188, and Bailey, Modern Social Conditions, p. 97.

§Abstract 13th Census, p. 128.

‖Estimate from Reports Commission General of Immigration, United States, 1909, 1910, 1911, 1912, 1913.

sible that this rate is too low.* On the other hand, since the birth rate of populations migrating to communities having higher standards of living tends to decrease and since most of the immigrants are derived from rural Europe and settle in cities, it may be concluded that greater economic opportunities here do not largely increase the rate.

A further estimate is necessary before this rate can be applied to the immigrant population. The net immigration of 5,243,000 suffered a death rate during the decade, the decedents being eligible to increasing the population before death. On the basis of the average mortality rate of that decade there should have been enough decedents to swell the child bearing immigration to 5,651,000. From the application of the above birth rate, it is found there would be born 1,130,000 children during that period of time.

But the children born to immigrants suffer a decrease by death during the ten year period. According to a probability curve drawn from Forsythe's Life Tables,† about 18 per cent. of the population dies by the tenth year of age. While this rate may be too low for the class of children in question it must be used because of the dearth of other figures. This reduces the number of children to 916,500. Dividing this sum by 5,243,000, the decennial increase rate for the immigrant population of 17.4 per cent. is obtained. As the result of this series of computations concerning immigration, it is found that there is a numerical population value of the specific net immigration amounting to 6,159,000.

The entire potency of the 1900 population for increase is measured by decreasing the decennial gain in population, 15,977,691, by the total force of the net immigration, 6,159,000, and increasing the result in turn by the amount of emigration plus its increase, 588,000. Dividing the resulting 10,407,000 by the 1900 population, 75,994,575, the resulting percentage, 13.7, is the rate expressing the power of that population to reproduce.

The actual increase, however, is expressed by the percentage obtained by disregarding emigration and the natural increase

*See Ellwood, Sociology and Modern Social Problems, p. 176, and Report of Immigration Commission, Vol. 2, p. 497.

†Quarterly Publications, Am. Stat. Assn., Sept., 1914, p. 234.

of immigration, a percentage of almost 14.2. This latter percentage is slightly below the figure, 14.8, suggested by the census bureau at the 13th census.* And the potency rate of 13.7 per cent. is also below the census approximation of 14.0.

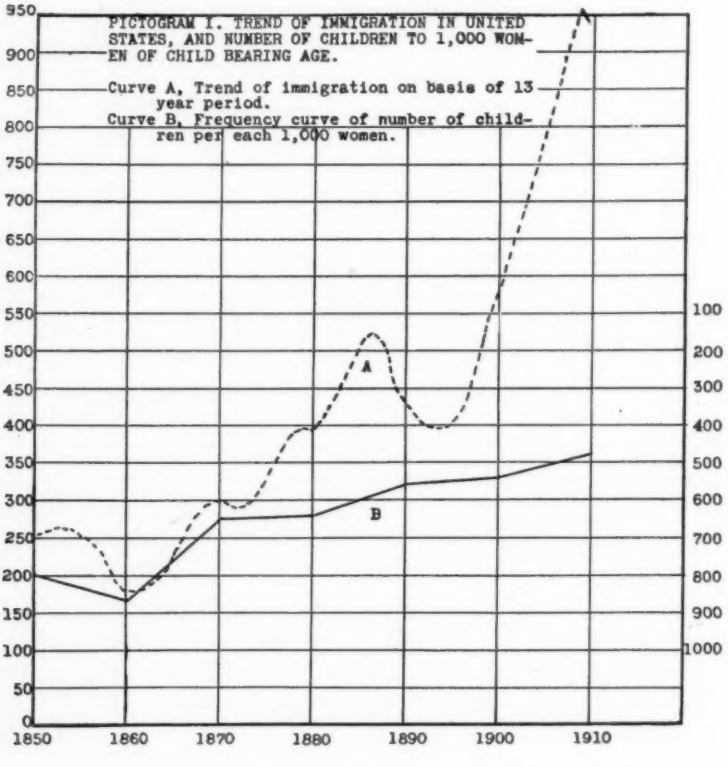
It is seen that immigration contributes a large share of the decennial increase of population. On the basis of the foregoing estimate its contributing power is $21-13.7\div21=34.7$, practically 35 per cent. During the three decades, 1790–1820, previous to the coming of immigrants in force, the decennial increase of population averaged 34.5 per cent., practically all of which was due to natural increase. That rate, less the present rate of 13.7, marks the decline in the rate of natural increase, a decline of over 60 per cent. of the original rate. The earlier rate is over two and a half times as great as the present rate. The consideration of the decline in the rate of natural increase yields a more direct and vivid picture of the movement of a modern nation in the direction of the much discussed "race suicide" than does a study of the decline in the birth rate, because, unless the latter is accompanied by similar study of the death rate, only hazy conclusions can be drawn. For real race suicide occurs only when the death rate exceeds the birth rate.

The question, as to whether or not immigration to this nation has really increased our population, might appear ridiculous in the face of the fact that during the last census decade that influx contributed 35 per cent. of the increase of our population, and likely accounted for quite as large a proportion of the gains during the more recent preceding decades. Yet some intelligent students of the question have so held, claiming that had not the immigrants come in competitive numbers our national rate of natural increase would have continued sufficiently high to offset our gains in population from immigration.

The fact is, however, that the birth rate of the United States was decreasing before the heavier waves of immigration struck our population. This heavy pressure evidently was not serious prior to about 1850. The ratio of foreign born to the population at that date was 1 foreign born person to 9.5 of

*Abstract 13th Census, p. 78.

the population in general. The next decade it rose to 1:7.6, from which it has not greatly varied since that time. The ratio was 1:19 in 1840 and 1:48 in 1830. The two latter ratios are estimated on the basis of the ratios of the successive decennial amounts of foreign born population from 1850 to 1870. Our birth rate doubtless would have decreased had there been only slight or no immigration, since other nations which have received little immigration have suffered a decided decrease of such rate. But it is somewhat apparent that immigration has affected the increase rate of the native stock. This is seen in the relation of the frequency curve (Graph I) of the number of children under 5 years of age per 1,000 women of 15 to 44 years of age, from 1850 to 1910, to the curve of the trend of annual immigration, drawn on the basis of a thirteen year



period, for the same time.* The variations of the former synchronize with the undulations of the latter in a striking manner. Of course, it is possible to say that the conditions which cause the fluctuations in immigration also produce similar changes in the rate of natural increase. No doubt there is a degree of truth in this statement.

Some have sought to demonstrate that it is urbanization which lowers the rate of population increase rather than immigration. Thus Goldenweiser offers selected statistics in support of this contention.† He places in parallel columns the "percentage of population living in the cities of at least 25,000 inhabitants: 1900," the "percentage of population foreign born: 1900," and the "number of children under 5 years of age per 1,000 native white women 15 to 44 years of age: 1900." Upon inspection, he pronounces an apparent correlation between the number of children and urbanization rather than between the former and immigration.

The correlation he considers apparent is not conclusive, however, for upon application of the scientific principle of correlation to his data it is discovered that the coefficient of correlation in favor of the influence of immigration on the number of children is greater than is that of urbanization, the former being .73 and the latter .66.‡ While, from these coefficients, a decisive case cannot be made out for either immigration or urbanization exclusively, yet since the coefficient for immigration is larger than that for urbanization it would appear that the former possesses the greater causal relation to the birth rate.

However, should we regard the factor of foreign born population as a more accurate measure of the pressure exerted on our native born population than the element of immigration, the above conclusion drawn from Goldenweiser's data would have to be reversed, since the coefficient of correlation between the foreign born factor and the number of children to 1,000

*For estimates of number of children, see article by Walter F. Willcox, QUARTERLY PUBLICATIONS of the American Statistical Association, XII, p. 491; the trend of immigration was made from data given in the Reports of the Commissioner General of Immigration.

†American Journal of Sociology, Vol. XVIII, pp. 348-350.

‡I desire to acknowledge my indebtedness to my colleague, Dr. George R. Davies, for suggesting the correlation between the frequency curve of children of fecund women and the fluctuations in immigration, and for the coefficients of correlation between the various factors in Goldenweiser's table.

women of child bearing age is only .38. Probably there is good reason for thinking of the pressure exerted by the foreign born on our native population as the truer index, since it is the permanent factor in the situation, immigration fluctuating according to conditions.

No doubt immigration has been a factor in causing a reduction of the birth rate in the United States, but that it is the sole factor cannot be sustained in the face of the fact that other states and nations having little or practically no immigration have sustained quite as large or greater decrease in their birth rates. That urbanization is an important causal factor in reducing the birth rate must be concluded from an inspection of the decennial rates of natural increase presented in columns 8 and 9 of Table I. When it is noted that the rural rate is almost twice the urban rate for the nation as a whole, that in only one division does the latter exceed the former, and that in some divisions the rural rate is three times the urban rate, it can scarcely be doubted that the factor of urbanization is the most important cause of lowered increase rates. Urban birth rates are lower than rural birth rates and its death rates are higher than those of the latter.

The task of securing rates of natural increase for rural and urban communities is a difficult undertaking, because data for their immediate determination are deficient. Had we mortality and birth data for them it would be a simple matter to obtain their difference. But trustworthy registration of births obtains for only New England and a few cities in other divisions, and the registration area for deaths embraces only about two thirds of the national population, many states and some divisions being without complete registration. And while nothing like an exact estimate can be made in view of these conditions, I believe it is worth while to make an initial calculation, trusting to time either to perfect it or to develop complete registration of births and deaths.

One method of securing natural increase rates for rural and urban districts is to find a substitute method of deriving births and to approximate death rates in states not having them.

If the census reported the number of children living in urban and rural communities under one year of age, we need only

to discover the portion of children who had died to obtain the number born. But the best the census does is to give the number of children under five years of age living in such districts.

By the use of a frequency curve constructed from data furnished by Forsyth's Life Tables* it is possible to calculate the average age and conversely the average number of children who died within the five year age group. The life table represents the elimination by death obtaining among a given number of persons all of whom begin life at the same moment, and it might appear that a probability curve erected on such a basis would misrepresent a curve constructed from the data of an actual population in which at each point of time, during the five year period, infants are being born. But an analysis of the latter data shows that the two situations are similar and that their probability curves are practically identical. For the whole United States population such a curve yields approximately 86 as the average percentage of children, out of all those born during the five years, who are living: conversely the average percentage dying is 14.

But the life table does not distinguish between cities and country and it is most likely that child mortality is somewhat greater in the former than in the latter. Evidently the rural percentage should be less and the urban percentage more than 86. The approximately correct percentage in each case was determined by the following method of calculating rural and urban mortality rates for rural and urban children under 1 year of age, discovering their ratio, and applying it to the five year age group.

Of the Negro population, 2.6 per cent. and of the white, 2.4 per cent., are under 1 year of age.† But the application of 2.4 per cent. to both rural and urban populations does not yield the total number of children of that age. For the national population, also, 9.9 per cent. of the urban and 13.0 per cent. of the rural are under 5 years of age. The same disproportion must be true of children under 1 in the groups, since the ratio of registered deaths in rural districts of the one year and five

*Quarterly Publications, Am. Stat. Assn., Sept., 1914, pp. 228–235.
†Census 1910, Vol. I, p. 314.

year age groups and that in urban districts of similar age groups are almost identical, being 72.0 and 71.3, respectively. Hence, with 2.4 per cent. as a basis, multiples which, applied to urban and rural populations, will produce the census number of children under 1 year of age, may be obtained by trying out 2.39, 2.38, etc., for urban and 2.41, 2.42, etc., for rural. It is found that 2.25 applied to the urban population and 2.55 applied to the rural population produce the census number of children under 1, a difference of 6.2 per cent. in favor of the rural. Proceeding in the same nanner relative to Negro infants, the corresponding rates of 2.2 and 2.8 are established.

From the Mortality Report* it is possible to estimate the number of Negro children who survived at the end of a year by taking 2.8 per cent. of the rural and 2.2 per cent. of the urban population, and by the use of the number of deaths reported in each case, estimate the infant death rates. The consequent rural Negro infant death rate is 11.6, and the urban rate is 18.7. The rates established for white infants are: rural, 7.96; urban, 11.9. Weighting the rural rates in each case by their respective white and Negro populations and treating the urban rates in like manner, there ensues a rural infant death rate of 8.5 and an urban rate of 12.3. Should we desire to weight these in turn by their respective populations, a national infant death rate of 10.25 is established.

Granting that the same difference between the rural and urban death rate for children under 5 exists as for those under 1, it is not difficult to determine how the previously obtained 86 per cent., the average percentage of children under 5 who are living out of all who were born, is to be distributed to rural and urban groups. For if $(91.5+87.7)\div 2=89.4$, then $\frac{x+y}{2}=86$. Then $91.5 : 87.7 :: x : y$. Whence x equals approximately 88 and y equals approximately 84. Hence the average percentage of rural children under 5 who survive is 88, that of urban children, 84.

We may proceed now to apply these rates to rural and urban populations. In 1910 there were 4,200,291 urban children under 5 years of age. Since these represent 84 per cent. of

*1911, p. 150.

those born, the number of births must have been 5,000,000. Dividing this number by the urban population midway between 1907–1908, a rate of 25.2 is secured as the birth rate. Proceeding to apply the rural percentage, 88, in the same manner, a rural rate of 30.3 is obtained.

As a result of applying 84 per cent. to the urban population of each of the divisions of the United States and 88 per cent. to their rural populations, urban and rural birth rates are established for the nine divisions. These birth rates will be found in columns 1 and 2 of the accompanying table, Table I. Column 3 contains the birth rates of the several division populations. These rates were established by weighting the rural and urban rates with the rural and urban populations of 1900. It is seen that division rural birth rates have a range of over 16, the lowest being 21.0, New England, and the highest, 36.4, West South Central. There is a much smaller range in the urban communities, the Pacific being the lowest, 20.4 and the West South Central the highest, 27.0. As to division rates, the Pacific has the lowest, 23.1, the West South Central the highest, 34.1. To most persons it will be a surprise to learn that the Pacific division has a lower birth rate than New England.

TABLE I.

RATES OF BIRTH, DEATH, AND NATURAL INCREASE IN THE UNITED STATES FOR THE DECADE 1900–1910.

Division.	Birth Rate.				Death Rate.			Rate Natural Increase.		
	Rural.	Urban.	Total.		Rural.	Urban.	Total.	Rural.	Urban.	Total.
			Present Estimate.	Children's Bureau Estimate.						
New England..	21.0	24.4	23.6	24.4	16.0	17.1	16.9	5.0	7.3	6.8
Middle Atlantic	25.5	26.4	26.0	26.2	14.8	16.8	16.2	10.7	9.6	10.4
East North Central.....	25.2	24.7	25.2	24.2	12.8	13.9	13.4	12.4	10.8	11.6
West North Central.....	28.4	22.5	26.3	25.5	10.3	12.4	11.0	18.1	10.1	15.8
South Atlantic.	34.4	25.4	32.1	31.2	15.5	19.4	16.4	18.9	6.0	16.0
East South Central.....	34.4	25.4	32.2	31.6	14.7	18.0	15.3	19.7	7.4	17.8
West South Central.....	36.4	27.0	34.1	32.2	12.5	16.8	13.4	23.9	10.2	21.6
Mountain.....	31.6	25.5	29.4	27.0	10.5	15.0	12.1	21.1	10.5	17.6
Pacific.....	24.6	20.4	23.1	19.9	12.0	13.8	13.0	12.6	6.6	9.8
United States	30.4	25.2	28.6	(27.1)	13.5	16.4	14.7	16.9	8.8	13.65

It will be noted that the New England and Middle Atlantic divisions are the only ones in which the rural birth rates are lower than the urban. This is probably due to the large foreign born population, chiefly urban, with its high birth rate. The Southern divisions generally, show a much greater difference in this respect than do any other divisions, the disparity arising from large variations in the rural rates, there being no pronounced fluctuations in the urban rates. The presence of the prolific Negro population in those divisions doubtless accounts for this condition.

With the above division birth rates may be compared the estimates of the United States Children's Bureau.* The fourth column, Table I, contains these estimates. That for the United States in this column results from totaling the number of children reported for the various divisions and dividing by the population of the United States. The two sets of estimates are not far apart, save in the last three divisions. The author's estimate is, however, supported by the following evidence: First, the rate for the nation, 28.0, obtained by weighting the division rural and urban rates is almost identical with the national rate, 28.1, secured by obtaining separate birth rates on the basis of the total number of rural and urban children under 5 in the whole nation and proceeding to weight them. Second, these rates agree with that obtained by treating the children of the nation, irrespective of divisions, and of the rural and urban communities. Third, the rate of natural increase for the United States as determined in the earlier part of this paper, is almost identical with that obtained by the use of the birth and death rates presented in Table I.

As has been indicated, the mortality rates contained in the United States Mortality Reports, cover only about two thirds of the national population, none being available for many states and for one entire division. Yet the distribution of the area from which reports are made is such that a mortality rate may be approximated for neighboring and similar areas. Space does not permit of giving the reasons for my estimates for the various states that do not report on mortality. Suffice to say, I have given each state careful attention.

*Birth Registration, Monograph No. 1, 3d edition, 1914, p. 18.

The mortality estimates in Table I were made on the basis of the data given in the Statistical Abstract of the United States.* Column 5 presents the simple average of published and approximated mortality rates of the states as urban rates by divisions, and column 6 contains the same results for urban communities by divisions. The rates presented in column 7 were obtained by weighting the rural and urban rates in columns 5 and 6. The national rural and urban death rates are the average for the five years, 1906–1910, that for the nation as a whole represents the weighting of all the division rural and urban rates.

The rates for the West North Central and the Mountain divisions seem low. It is possible that they are too low, but it is to be remembered that it is altogether probable that both the climatic conditions and the age distribution of the populations of these divisions are favorable to the existence of low rates. The reports of mortality from such states as make reports may all be wrong, but the reports we get certainly indicate that the conditions of life in those sections favor longevity.

Columns 8, 9, and 10 of Table I, embody the results, for most part, derived from a treatment of the rates contained in the columns under Birth Rate and Death Rate. The rural column exhibits a relatively steady increase of rates, beginning with New England and proceeding toward the Pacific. A vast fluctuation in these rates is obvious, those of the West South Central and Mountain divisions being from four to five times the New England rural rate. It is seen, that should the indicated rate persist, the West South Central division would almost double its population in four decades by natural increase alone. In the same manner it would require New England 200 years to accomplish that result.

The urban column offers its surprises in that three other divisions show as low a rate of natural increase as either New England or the Middle Atlantic. Since the Negro population in the South is largely a rural population, it is plain that the native white stock of the southeastern divisions are multiplying about as slowly as is that of rural New England. The native white stock of urban New England is doubtless in the

*1913, pp. 74–75.

same or even in a less fecund condition, since its urban rate is largely sustained by the more prolific immigrant stock. It is also noteworthy that the Pacific urban rate is less than that of New England. This is partly due to the fact that the population of this division contains an unusually large percentage of individuals from 25 to 44 years of age and of unmarried males and females. It is probable also that the native stock has approximately the same tendency toward infecundity exhibited in New England and the southeastern cities.

The national rural and urban rates in each instance are derived in the same manner as are the division rural and urban rates, by taking the difference between the national birth and death rates. It certainly is a matter of surprise that the rural rate is almost double the urban rate. The assumption which is found repeatedly in published works is that the urban birth rate exceeds the rural rate, and the conclusion is usually drawn that the natural increase of the former is consequently greater.

The total rates of natural increase are the weighted averages of the rural and urban rates, division by division. As in the case of the rural column, a progression is noticed in the size of the rates from New England down to the West South Central division, a decline occurring after that. The Pacific rate approximates that of the Middle Atlantic. That of the West South Central division is more than three times that of New England and over twice that of the Middle Atlantic or the Pacific. Those who believe in economic determinism will find comfort in this column, for it is apparent that the rate of natural increase largely follows the pressure or freedom from pressure of economic opportunities. However, a second thought reveals the fact that race and standards of culture play a large rôle, because the highest rates are in the division that include the bulk of the Negroes, where heavy breeding occurs in spite of their backward economic conditions.

When the results embodied in the last three columns of Table I, especially those of the rural and urban rates, were obtained, the writer was inclined to think a huge mistake had been made. But a careful and repeated reëxamination of the data and processes on which the results depend compel him to think the findings are essentially true. Should it be said that

the birth rates are too high or too low, the reply is that they must be so for all of the divisions, for the same method was applied to all data alike. And should it be said that the mortality rates for certain of the divisions are too low, the answer is that then they are too low alike for the rural and urban communities of the divisions, for the same method was applied in every case. The result would be that there might be a small modification of urban and rural death rates in some divisions, and a slight lessening of the natural increase rates in general due to a uniform reduction of the birth rates. But the results would not be changed greatly. Consequently, Table I gives a comprehensive and, I believe, a fairly accurate picture of the situation for the United States as a whole, for the several divisions, and for rural and urban communities as regards the vital facts of natural increase.

In concluding this treatment of natural increase, I desire to remark on the close agreement existing between the rate of natural increase, 13.65, to be found at the foot of column 10, Table I, and that of 13.7 obtained by an analysis of the population increase between 1900 and 1910 into its factors of emigration, immigration, and native born. The latter percentage, 13.7, was first obtained and the fact that the former percentage was so nearly identical was regarded as an indication that the methods by which it was secured were reliable. To the writer, this agreement is no small evidence that the birth rates and the death rates contained in Table I are approximately correct. Were they considerably modified the resulting rate of natural increase for the nation would, by the amount of the modification, fail to agree with the first established rate.

One of the most interesting undertakings in the field of the statistics of population is that which deals with the factors that account for growth of population and seeks to accord to each one its relative force in producing the change. Little of a scientific analytical character has been done toward the accomplishment of this object and the territory is practically a virgin one. We know relatively nothing in an exact way regarding the forces at work in the population of our nation until this task is accomplished, and the hope of contributing something that will serve as a foundation for further attain-

ments in that direction is a sufficient spur to drive a worker into this complicated and difficult field.

The elements that enter into the rural and urban changes of our national population in the direction of determining its growth are: natural increase, emigration, immigration, incorporation, and rural migration.

In round numbers the increase of urban population during the last census decade was 11,826,000. This is to be credited to incorporation, immigration, and natural increase. Had it not been for emigration the gain would have been larger. This emigration from urban districts amounted to 294,000, therefore the potential urban increase for the decade totals 12,120,000.

According to the Census, incorporation means three things: the addition of suburban territory to urban districts; the growth of rural villages past the 2,500 population point, the dividing line between rural and urban communities; and the falling back of some urban communities into the rural class. During the decade, ending 1910, approximately 813,000 inhabitants passed over into the urban group according to the census figures. Computing the increase of this population by applying the national natural increase rate already established, the final urban increment by incorporation is found to be 924,000, or 7.8 per cent. of the urban increase.

Immigration is the largest factor in accounting for the increase of urban population. The foreign born population of the United States in 1900 was 10,341,276; in 1910, 13,515,886. In 1900, 66.8 per cent. of the white foreign born population was urban, and in 1910, 72.2 per cent. Consequently the urban foreign born in 1900 must have been 6,908,000 and that of 1910, 9,745,000. To the former number belongs also that portion of the foreign born rural population which became urban by 1910, a sum of 111,000, swelling the 1900 urban foreign born population to 7,019,000. Since, as we have seen, but 80 per cent. of this population remains by 1910, or 5,615,000 the net immigration for the decade was 4,130,000. Increasing this sum by 17.4 per cent., the rate formerly established to represent the decennial natural increase of immigrants, it is found that the national urban population was enlarged by

reason of immigration, by 4,849,000, or 41 per cent. of the total urban gain.

How far is the urban gain in population to be accounted for by the natural increase of the population resident in urban districts in 1900? Our urban rate of natural increase has been established during the preceding treatment (See Table I, column 9). Applying this rate, 8.8 per cent., to the urban population of 1900, 30,797,000, gives 2,710,000 as the amount of such natural increase. But since urban populations sustained a decennial loss of 294,000 by reason of emigration and since, it may be assumed, this loss was sustained chiefly by the population that was present in 1900, the amount of natural increase may be diminished by the amount of emigration, leaving a balance of 2,426,000 to be assigned to natural increase. This represents 20.5 per cent. of the urban decennial gain.

It is now possible to estimate the amount of rural immigration by taking the difference between the sum of the ascertained factors and the decennial urban increase. In round numbers this amount is 3,637,000, or 30.7 per cent. Hence we may gather the results in Table II:

TABLE II.

FACTORS OF URBAN INCREASE FOR THE UNITED STATES AS A WHOLE, 1900-1910.

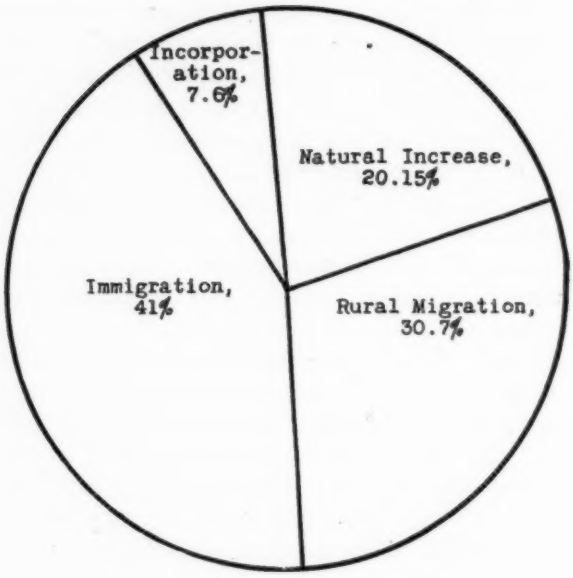
Factor.	Amount.	Per Cent. of Urban Increase.
Incorporation	924,000	7.8
Immigration	4,849,000	41.0
Natural increase	2,426,000	20.5
Rural migration	3,637,000	30.7
Total	11,826,000	100.0

The results of this table may be presented in graphic form.

The proportion of these urban factors to each other differs but slightly from that given in the published estimate* previously referred to. But my figures vary widely from those given by Mr. Earl Clark in his paper "Contributions to Urban Growth."† Mr. Clark did not seek, however, to estimate the amount net immigration is swelled by its own natural increase which is found to represent over 718,000 persons. Neither

*See QUARTERLY PUBLICATIONS of the Am. Stat. Assn., Sept., 1915, p. 649.
†*Ibid.*, p. 671.

GRAPH II. RELATIVE FORCE OF FACTORS DETERMINING URBAN INCREASE IN THE UNITED STATES, 1900–1910.



did he deal with the factor of incorporation which we have seen affects the situation in various ways, although he excludes the incorporated population from his total urban increase. It may be said further, that he did not have the advantage of the detailed results of the work on natural increase of population which are presented in this paper.

It will not be necessary to indicate the detailed calculations made in arriving at the results representing the factors concerned in the rural increase for the United States during the decade. The methods and processes were in general similar to those involved in the urban analysis. It is well to note, however, that both incorporation and rural migration in Table II represents rural losses, in addition to the factor, emigration. Thus, to secure rural migration, from the sum of immigration and natural increase is taken the sum of incorporation, emigration, and census estimate of rural increase.

These amounts are as follows: Immigration, 1,290,000; natural increase at rate 16.9, 7,638,000; total gain in popu-

lation, 8,928,000. From this is taken: Census increase, 4,151,000*; incorporation, 924,000; emigration, 294,000; total, 5,369,000. The difference, which represents rural migration, is 3,559,000.

The results of rural analysis for the nation as a whole are embodied in the following table:

TABLE III.

FACTORS OF RURAL INCREASE FOR THE UNITED STATES AS A WHOLE, 1900–1910.

Factors.	Amount.	Per Cent. of Census Increase.
Immigration	1,290,000	31.0
Natural increase	2,861,000	69.0
Total	4,151,000	100.0

It is observed that only about 37.5 per cent. of natural increase of rural communities is devoted to accounting for the Census increase, the remainder being accounted for under the three factors of loss: emigration, incorporation, and rural migration. It must also be noted that the total rural increase is not the Census statement of increase but an amount derived by subtracting the rural population of 1900 living in territory that was rural in 1900 from the rural population living in rural territory in 1910. This is made necessary to permit the use of the factor of incorporation in estimating the force of rural migration. A difference of over 80,000 appears between the estimates of rural migration made for rural and urban populations. We shall find further variations from both of these estimates, as for the other factors, when we arrive at a closer analysis of rural and urban populations by divisions. Such variations are to be expected because of some uncertain elements in the computations, but it is hoped that they do not greatly militate against the value of the estimates.

It might seem a perfectly simple matter, since the force of each of the various factors has been determined for the nation relative to urban and rural districts, to apply the results to the divisions. But a consideration of a single division reveals new difficulties. Thus, how is emigration to be distributed

*Abstract 13th Census, 1910, p. 56.

among the several divisions so that each shall have its actual amount? And what is to be done with the new element in the situation, namely, the interdivision migration of native born persons?

To treat in detail each division, and to do the same for the urban and rural districts in each division, would require too much space. We shall have to be satisfied with a somewhat syncopated handling of a single division and the presentation of the results from the other divisions in a comprehensive table. Divisions as a whole will first be considered; then a treatment of their urban and rural districts will be undertaken.

I have selected the Middle Atlantic division to illustrate the method of making estimates. Any other division would do equally well, since a uniform method is employed. The force of immigration is ascertained exactly as it was for the nation as a whole, and for the national rural and urban districts. The net immigration for the decade so ascertained is 2,197,466, its natural increase at 17.4 per cent. is 382,000, giving a total immigrant contribution beyond the population of 1900 of 2,579,000. Since the increase of population for the division as recorded by the Census was 3,861,214, immigration with its natural increase constitutes about 67.0 per cent. of such increase.

Since emigration enters into the calculation of the potency for natural increase of the 1900 population it must be regarded. Had we to consider only accounting for the Census amount of increase it might be disregarded. Its consideration also is demanded as a foundation for calculations relative to the factor of rural migration to be determined hereafter.

There is no certain indication for distributing the effect of emigration among the divisions. One might expect that the drain from some divisions would be proportionately larger than from others. I have made calculations for all entire divisions, as well as for their respective separate rural and urban parts on the basis of several different assumptions. The criterion of availability applied to these methods, as also of those regarding the various modes of treating interdivision migration of native born Americans, has been their effect on the amount of rural migration as separately determined for

rural and urban regions (Tables II and III). In each case, I have concluded that the one which secured most nearly identical sums of rural migration in the respective divisions when determined by the two processes of analysis, rural and urban, was the one most nearly correct. As a consequence I have returned to my initial plan of distributing the effects of emigration among the divisions in proportion to their population, and within divisions between urban and rural according to their respective populations.

In 1910 the rural and urban populations of the United States were so nearly equal that the sum of emigration was halved and an equal portion allotted to city and country alike. Since the total amount, not increased by natural gains, was estimated at 550,000, urban and rural regions would each suffer a loss of 275,000. Middle Atlantic urban population in 1910 formed 32.2 per cent. of the total national urban; hence its allowance of emigration was 88,500. In like manner rural Middle Atlantic, since its population was 11.3 per cent. of the national rural, was assigned 31,050. Since the decennial urban rate of natural increase is 9.6 per cent. (Table I) and the rural 10.7, the assigned sums are increased to 93,400 and 32,650, respectively. The urban amount, 93,400, constitutes approximately 2.4 per cent. of the Census increase of the division.

According to the Census report* Middle Atlantic, in 1910, had 932,467 more persons born within the division who lived outside it than it had native born of other divisions living within itself. But compared with the record of 1900, when the difference against Middle Atlantic was 1,088,150, the division really gained in native born; that is, the division was 155,683 better off in 1910 than in 1900. The first assumption likely would be that the latter amount is the sum we need and represents a gain in population. But, as is the case with other factors, logical analysis of the situation is found to be necessary in order that the true force of the migration of this element may be discovered.

Each division relative to the native born migrant must be viewed and treated just as the nation is viewed and treated

*13th Census, Vol. I, p. 693.

relative to foreign born. There is an inflow and an outflow, births and deaths, and these modifying factors must be measured. Hence a double analysis must be made; one for those born in the division but living outside for 1900 and 1910, and one for those born outside but living within for both dates.*

For Middle Atlantic in 1900, persons born in the division but living outside numbered 1,808,060. These would suffer inroads by death during the decade, and I have used the national decennial death rate of 15 per cent. for all divisions. I consider this better than the separate division mortality rates, since there is no way of knowing what length of time the migrants have been acted on by the local rate. Consequently only 1,538,000 are living by 1910. In 1910, those who are born in the division but live outside it number 1,881,406. The difference, 343,400, between this sum and 1,538,000 represents the gain in the number living outside the division.

In the same manner, persons born outside Middle Atlantic living inside in 1900 numbered 719,910 of whom 620,000 are living in 1910. Persons of the same character at the 1910 Census number 948,939, the difference between this and the survivors representing a net gain of 329,000.

These amounts, 343,400 and 329,000, are also influenced by the decennial rate of natural increase. For the same reasons given for the use of the national instead of the local death rate, I chose the national rate of natural increase, 13.7. Applying this rate to each amount, they become 367,800 and 352,000 respectively, wherefore their difference, 15,000, represents the loss of native born to other divisions Middle Atlantic sustains. Hence what seemed to have been a great loss, the Census 155,683, by analysis of the situation appears as a small one. And the same is true in the case of all eastern divisions whose census record appears positive.

Having ascertained the value of each of the factors, immigration, emigration, and migration of native born, it is possible to discover the amount of natural increase by a new method. Since the latter two factors represent losses of the 1900 population, they must be added to the Census increase of 1910 to discover what the full potency of the former population act-

*For Census data, 13th Census, Vol. I, p. 692.

ually was, giving a total sum of 4,002,264. From this is taken immigration, 2,579,000, leaving the amount of natural increase, 1,423,264. Dividing the latter amount by the population of 1900, a rate of natural increase of 9.2 for the division is obtained. By our other method of securing the division rate of natural increase, a rate for the Middle Atlantic division of 10.4 was established.

When the same method is applied to each of the other divisions as was just applied to the Middle Atlantic, the data to be found assembled in Table IV are obtained.

Relative to this table of results some remarks are pertinent. Lest there be a misunderstanding as to what the totals imply, it is sufficient to say, first, that column 5 plus column 7 less column 2 should equal the total in column 1. The difference is about 23,000. Second, the total in column 2 should equal the original total estimated for the United States, 588,000. The difference is seen to be slight. Again columns 3 and 4 should balance, but the difference is only about 5,000. Finally, the force of immigration as originally estimated for the nation was 6,159,000, as compared with the total of 6,153,000 of column 5. A portion of these small differences no doubt are due to the use of the slide rule in most of the hundreds of computations involved in evolving the table. Some of the differences are evidently due to the application of uniform rates of death and natural increase to widely differing populations, as in the case of immigration and of the native born migrants. But considering the complexity involved, it is rather remarkable that the divergences are not greater. For instance, to secure the amount of natural increase for the several divisions and the nation involved the treatment of the new factor, native born migration, yet the difference between the total so secured, 10,429,000, differs from the original estimate, 10,412,000, by only 17,000.

Only three divisions, all western, add to their population by means of an actual excess of income over outgo of native born Americans. Column 6 shows that immigration contributes slightly to the increase in the South and Southeast but that its force in that direction is preponderent in the North and Northeast.

TABLE IV.

FACTORS ACCOUNTING FOR INCREASE OF POPULATION BY DIVISIONS, 1900-1910.

Division.	Increase According to Census.	Loss.		Gain.							
		Emigration: Number with Increase.	Migration Native Born: Number with Increase.	Immigration.		Natural Increase.			Actual Contribution to Census Increase.	
				Number with Increase.	Per Cent. of Census Increase.	Amount.	Rate.	Per Cent. of Census Increase.	Amount.	Rate.
New England	960,664	42,830	22,000	.....	784,000	81.5	241,494	4.3	25.0	176,664	17.3
Middle Atlantic	3,861,214	126,050	15,000	.....	2,579,000	66.7	1,423,364	9.2	36.9	1,282,214	33.2
East North Central	2,265,040	116,400	688,000	.....	1,142,500	50.0	1,927,200	12.0	85.0	1,122,460	50.0
West North Central	1,290,500	73,400	658,000	.....	457,906	35.5	1,563,900	15.2	121.0	832,594	64.5
South Atlantic	1,751,415	75,840	104,000	.....	149,270	8.0	1,781,985	17.1	102.0	1,602,145	91.0
East South Central	862,144	53,980	457,700	.....	18,050	2.0	1,355,800	17.0	157.0	840,094	97.4
West South Central	2,252,244	55,500	.....	470,000	162,622	7.2	1,675,000	25.5	74.0	1,619,600	72.0
Mountain	958,860	16,700	.....	450,800	248,597	26.0	276,160	16.5	29.0	259,400	27.0
Pacific	1,755,612	26,300	.....	1,006,000	609,827	34.5	186,700	7.7	10.6	160,000	9.0
Total	15,977,669	581,600	1,937,000	1,932,000	6,153,000	....	10,429,000	....	.....	.....	....

Column 8 gives the rates of natural increase established by the method of division analysis. In general, they confirm the findings in Table I, column 10. In four divisions the difference of rates is less than 1 per cent., in two others slightly more than 1, in two others between 2 and 2.5, and in one 3.9. Nor is one set of rates uniformly higher than the other. Thus the rates in Table I exceed those in Table IV only in the New England, Middle Atlantic, West North Central, Mountain, and Pacific divisions. The weighted average for all the divisions gives practically the same rate of natural increase for the United States as obtained by the other method, 13.7 vs. 13.65, and agrees with the rate previously established for the nation.

The difference between the two sets of rates may be due, in New England, to the fact that the estimated rate of natural increase for immigration is larger than conditions of life in that division justify. If this assumption is true, the new rate of natural increase for the division population would be increased by that much. The very large rate in the West South Central division may be due to applying the national mortality rate to the native born migrants treated relative to that division, when the local death rate is higher and should have some influence in the estimate. However, I know of no means of taking such considerations into account.

The actual contribution to the division increase as recorded in the Census, given in column 10, differs from the amount of natural increase. In the first six divisions this contributive amount is ascertained by obtaining the difference between the Census increase and immigration; in the last three divisions, by finding the difference between the Census increase and the sum of immigration and native born migration. In the case of the East South Central division it is apparent that the Census increase would have been over one and a half times its actual amount had the native born loss not occurred.

The factors which enter into the determination of the urban increase in each of the various divisions are those discovered in making calculations for each division as a whole, together with the new elements of incorporation and rural migration, both of which entered into the analysis of the national increase with respect to urban and rural. The force of the various

TABLE V.

URBAN INCREASE IN THE UNITED STATES, 1900–1910.

Division.	Increase According to Census.	Factors Affecting Urban Increase.															
		Losses.		Gains.													
		Emigration.	Interdivision Migration of Native Born.			Immigration.		Incorporation.		Natural Increase.					Rural Migration.		
			Amount (Loss).	Amount (Gain).	Per Cent. Census Increase.	Amount.	Per Cent. Census Increase.	Amount.	Per Cent. Census Increase.	Amount.	At Rate.	Per Cent. Census Increase.	Contribution to Census Increase. Amount.	Contribution to Census Increase. Per Cent.	Amount.	Per Cent. Census Increase.
New England	985,166	32,150	18,160	.....	....	742,000	75.4	20,800	2.2	210,000 326,000	4.7 7.3	21.3 33.0	160,000 213,000	16.2 21.5	62,200 (a)53,800	6.3 0
Middle Atlantic	3,288,600	92,800	10,620	.....	....	2,207,000	61.0	254,000	7.2	975,000	9.6	23.8	513,000	15.6	314,579	8.7
East North Central	2,397,000	65,300	362,000	.....	....	1,005,200	42.0	182,000	7.2	780,000	10.8	13.3	342,700	14.2	857,100	35.8
West North Central	927,172	26,400	221,500	.....	....	261,640	28.0	83,820	9.0	297,600	10.1	32.0	49,460	5.3	532,252	57.0
South Atlantic	859,521	20,640	27,100	.....	....	90,000	10.5	111,300	13.5	134,000	6.0	15.6	186,060	21.5	572,161	66.5
East South Central	443,173	12,180	83,600	.....	....	14,100	0.6	59,200	13.4	83,600	7.4	18.8	(a)14,452	(a) 3.3	382,053	86.3
West South Central	900,259	13,450	.....	104,800	11.6	70,700	7.9	110,200	13.0	108,000	10.2	12.0	118,550	13.2	519,809	54.0
Mountain	406,148	6,370	.....	162,200	40.0	102,500	25.3	37,600	9.2	57,000	10.5	13.8	50,630	12.5	53,218	13.1
Pacific	1,260,000	15,900	.....	572,000	45.5	392,500	31.0	62,300	5.0	74,200	6.6	5.8	58,300	4.6	174,900	13.9
Totals	11,826,198	285,190	839,000	722,000	....	4,885,640	....	921,220	....	2,721,400 or 2,837,400	....	....	1,464,248 or 1,517,248	....	3,468,272 or 3,405,472	....

(a) Loss.

factors was reckoned much as was the rural and urban gains for the nation as a whole.

The results established by the analysis of these factors determining urban increase in each of the nine divisions have been brought together in the preceding table.

The amount of emigration and of native born migrants were obtained by apportioning the division total in each case (Table V, columns 2, 3, and 4) between the rural and urban districts of the division according to their population. As in the distribution of emigration among the divisions there seems to be no other principle to use in the apportionment. The force of immigration is obtained by the treatment of the urban foreign-born of 1900 and 1910 according to the method previously developed. The factor of incorporation calls for no explanation, except that it represents the population in the division that became urban between 1900 and 1910,* and that since it is involved in the process of reckoning natural increase, according to the meaning adopted in this paper, it cannot be disregarded. The amount of natural increase is found by the use of the division rate for urban population (Table I, column 8). It is impossible to determine it by a process of exclusion as was done in estimating the amount of rural migration. Thus, in the Middle Atlantic division, rural migration equals the difference between the sums involved in columns 1 to 3 and 6 to 10, Table V.

New England gives some difficulty respecting its rural migration. If the process applied to the Middle Atlantic division is employed, it is found that not only is there no population left to rural migration, but at the urban rate of increase for the division, 7.3 per cent. per decade, there is a deficit of nearly 54,000. A similar deficit occurs when the same operation is performed for the New England division as a whole. Evidently, local conditions make some of the rates established inapplicable unless qualified. Which of the factors is overrated, or whether several are involved, there is no cue to determine.

An attempt has been made to estimate what proportion of the urban increase of the several divisions is to be assigned to

*Abstract 13th Census, pp. 56-57.

each factor helping toward the gain. The results uniformly occur in the columns headed "per cent. of census increase." It will be noted that columns 13 and 14 estimate the contributive power of natural increase. The same might have been undertaken for any of the other factors of increase, instead, but it is more appropriate for natural increase, since it aids us to see how far natural increase is being displaced by other sources of population. In the case of New England, two estimates are given for natural increase and rural migration; one based on the established urban rate for the division; the other, on a rate obtained by proportioning the division rate of natural increase (Table I, column 10) to the urban part of the division population. With the smaller rate, not only are the amount and contributive force of natural increase enlarged, but the deficit in rural migration (column 15) is turned into a surplus.

Should a comparison be made between the totals for columns 2, 6, 8, and 10, with the estimates for each of the items made previously in this paper, it would be found that some variations from those estimates appear. Using round numbers for the previous and the present computations in their order the estimates are: immigration, 4,885,000 vs. 4,849,000; emigration, 285,000 vs. 294,000; incorporation, 922,000 vs. 924,000; natural increase, 2,721,000 or 2,837,000 vs. 2,710,000; and rural migration, 3,405,000 or 3,468,000 vs. 3,637,000 or 3,559,000. These variations are partly due, presumably, to the use of the slide rule and to local conditions which refuse to conform to general formula, chiefly the latter. The gains and losses due to interdivision migration of native born should balance, but it is observed that they are about 84,000 apart. It is obviously possible that apportioning this factor to urban and rural communities according to population fails to meet the exact needs of the situation.

In using the foreign born population of 1900 and 1910 in order to estimate the net immigration for the decade, it was necessary to reckon the total number from the number of foreign born whites given in the 13th Census.*

Table VI, which presents the results of a series of estimates to discover the force of the various factors determining the

*See Census 1910, Vol. I, pp. 175, 189, and 781.

TABLE VI.

RURAL INCREASE IN THE UNITED STATES, BY DIVISIONS, 1900–1910.

Division.	Increase According to Census.	Factors Affecting Rural Increase.												
		Gains.									Losses.			
		Immigration.		Natural Increase.					Migration Native Born.					
		Amount.	Per Cent. Census Increase.	Amount.	At Rate.	Per Cent. Census Increase.	Contribution to Census Increase. Amount.	Contribution to Census Increase. Per Cent.	Amount (Gain).	Per Cent. Census Increase.	Amount. (Loss).	Emigration.	Incorporation.	Rural Migration.
New England	(a)24,502	42,000	.....	35,920	3.2						1,840	6,330	20,800	44,628
Middle Atlantic	213,724	371,659	17.4	56,100	5.0	.....	.....	....	.....	.....	4,380	32,650	254,000	24,448
East North Central	(a)132,256	137,338	.....	550,729	10.7	260.0	.....	....	.....	.....	326,000	51,200	182,000	417,634
West North Central	363,326	196,199	54.0	1,086,984	12.4	.....	.....	....	.....	.....	439,000	47,000	83,820	797,378
South Atlantic	891,894	59,270	6.6	1,340,000	18.1	368.0	.....	....	.....	.....	76,900	55,200	111,300	602,454
East South Central	418,971	3,950	0.9	1,532,034	18.9	172.0	.....	....	.....	.....	373,400	41,800	59,200	456,610
West South Central	1,351,985	91,922	6.8	1,253,117	19.7	298.0	.....	....	.....	.....	.....	42,500	117,500	363,696
Mountain	452,712	146,097	32.0	1,283,669	23.9	95.0	.....	....	365,200	27.0	.....	10,330	37,600	228,806
Pacific	515,639	217,327	42.0	231,889	21.1	51.0	.....	....	288,600	64.0	.....	10,400	62,300	165,944
Totals	4,208,251	1,265,760	.....	155,736	12.6	30.0	.....	....	434,000	84.0	.....	10,400	62,300	218,714
				7,470,078	....	.....	.....	....	1,087,800	.....	1,221,520	297,410	928,520	3,295,264

(a) Loss.

growth of rural population, calls for little comment. As in the case of the urban total, I have made two estimates of the amount of natural increase, and of rural migration, for New England, based on the two different rates. The employment of the lesser rate in both urban and rural analysis gives fairly similar amounts of rural migration.

The sums expressing rural migration in Tables V and VI for the several divisions should, of course, be identical. In some cases they are very wide apart. I have worked out rural migration on the basis of several different kinds of modifications of certain factors. Thus I distributed emigration differently, assigning a greater share to certain divisions, and to the urban or to the rural in given divisions, than in the tables. I also tried interdivisional migration of native born according to the untreated census figures and according to the different rates of natural increase and of death. But the present plan has more nearly reconciled the two series of amounts of rural migration.

Column 6 of Table VI is especially interesting. It is observed that in three divisions the natural increase amounts to several times the actual division increase, that in others it is equal to or greater, and that in two the Census expresses a deficit, in one of which cases the amount of natural increase is over one million. This situation, of course, signifies that the other sources of population have been supplanting individuals born in the division or that the latter have gone to other divisions.

A comparison of the totals of Table VI with similar amounts previously estimated, as in the case of the figures in Table III, shows these differences: For immigration, 15,000; natural increase, 168,000; emigration, 3,000; incorporation, 4,500; rural migration, 304,000. The total for rural migration differs by 100,000 to 150,000 from those given in Table V, column 15. The division losses and gains also show a variation in totals of about 135,000. In a field of such extreme complexity, however, and where there is no known means of eliminating assumptions, the occurrence of divergences would be anticipated by the statistician.

A comparison of the estimates of rural migration and of interdivision migration of native born secured by the two sets of analyses which were made, the one rural and the other urban, is of assistance in explaining how the apportionment of the results of migration of native born between urban and rural communities may produce great fluctuations. For this purpose it is useful to draw those data together in a table.

TABLE VII.

RURAL AND URBAN AMOUNTS OF RURAL MIGRATION AND INTERDIVISION MIGRATION OF NATIVE BORN, BY DIVISIONS.

Division.	Rural Migration.		Interdivision Migration Native Born.			
			By Rural Analysis.		By Urban Analysis.	
	By Rural Analysis.	By Urban Analysis.	Loss.	Gain.	Loss.	Gain.
New England	44,628	62,200	.....	.....	.....	.....
Middle Atlantic	24,448	(a) 53,800	1,840	.....	18,160	.....
East North Central	417,634	314,579	4,380	.....	10,620	.....
West North Central	797,378	857,100	326,000	.....	362,000	.....
South Atlantic	602,454	532,252	439,000	.....	221,500	.....
East South Central	456,010	572,161	76,900	.....	27,100	.....
West South Central	363,696	382,053	373,400	.....	83,600	.....
Mountain	228,808	519,809	.....	265,200	.....	104,800
Pacific	165,944	53,218	.....	288,600	.....	162,200
	218,714	174,900	.....	434,000	.....	572,000
Total	3,295,264 or 3,275,086	3,468,272 or 3,405,472	1,087,000	1,121,520	839,000	722,000

(a) Deficit.

An inspection of the data in Table VII is sufficient to indicate that the differences between the amounts of rural migration in the first two columns might readily be accounted for on the supposition that the effects of interdivision migration of native born are not truly apportioned between rural and urban communities. Thus, in the West South Central division, the gains, rural and urban, if differently distributed between those districts, could easily reconcile the differences in the amount of rural migration given by rural and urban analysis. In the first two divisions, this is not so true. But a different apportionment of emigration losses would be sufficient to reconcile the divergencies there. These estimates must remain far apart, however, until some method has been

found to apportion the results of emigration and migration of native born according to the actual events. Meanwhile it will be best to state the amount of rural migration occurring in the different divisions in terms of the minimum and maximum furnished in columns one and two of Table VII.

Relative to the rural migration of the nation as a whole, we have found a range of estimates from 3,275,000 (Table VII, column 1), which was the lowest estimate given by rural division analysis, to 3,637,000 (Table II), the maximum, given by the analysis of the whole urban population of the nation. This is a range of 362,000, or about 10 per cent. of the maximum estimate. Perhaps the true estimate, if known, would fall somewhere between the two, approximating 3,500,000.

FORTY-FIVE YEARS OF U. S. NAVAL MORBIDITY STATISTICS OF DEGENERATIVE DISORDERS.

By Charles N. Fiske, M.D., *Surgeon, U. S. Navy.*

It might well be an old wag to say that the navy has had a floating population; ethnically this fact is as important as that its personnel is derived from the civil population; any observations concerning its inherent traits reflect with considerable accuracy corresponding conditions among civilians of similar sex, age, physique, and intellect. The word "accuracy" is used advisedly for the reason that these observations are unusually trustworthy from being made by specially trained officers who maintain constant relations with their clientele; this is particularly true of naval medical officers whose association with the navy personnel is continuous as compared with the casual observations of civilians who rarely consult their physicians so long as they consider their health normal. Moreover the military services are practically the only groups of our population concerning whom complete morbidity statistics have been published; their officers and men are undoubtedly the only large community of whom fairly frequent periodical physical examinations have been required and in whom the movement of disease has been recorded continuously for 45 years.

Standards of age, physique, and intellect for enlisted men who have constituted over 90 per cent. of the navy and marine corps have changed perceptibly but not materially for present considerations; for while the average age has been reduced and physical and intellectual requirements have certainly risen, the proportion of "continuous service" men as shown by percentage of reënlistments has probably increased sufficiently to offset any undue advantage attributable to more discriminating selection at recruiting stations in recent years.

Statements, more or less arbitrary, are becoming commonplace, to the effect that the degenerative diseases of mature age, such as the scleroses and malignant proliferations, are insidiously although steadily increasing among the general

population while preventive medicine is occupied with successfully diminishing morbidity and mortality from the exanthemata and infections of youth, the inference being that sanitation and hygiene should begin to be more concerned with the former. It may well be doubted if these familiar ideas, which already approximate the category of platitudes, are based upon precise data or even tenable premises. Let it be recalled that 25 years ago when appendicitis became the vogue it was generally questioned if the disease was at all prevalent during the preceding generations and it was only after extended delving into old case histories and supposedly antiquated medical literature that it was found to be by no means a new entity. Standards of living change; published intelligence increases; precision in diagnosis certainly improves, although yet remote from perfection; disease terminology and classification advance; hospital clinics serve classes of people varying from one decade to the succeeding; and surgical practice, medical art, and even the so called pure sciences can not be acquitted of insecure impulse and bias. Many such and other tendencies occur to invite pause when one is told that cancer is alarmingly on the increase or that the strenuous high tension, under which many (but not necessarily average) Americans are pursuing dollars, is bringing the nation to doom through Bright's disease and arterio sclerosis, when the influence of the compound microscope, Virchow's cellular pathology, and the sphygmomanometer may have been the insidious factors.

In the first place does it always occur to the fluent speaker and facile writer of medical altruism that, as Sir Victor Horsley believed, we have been sparing the weak and unfit in youth to furnish material for degenerative disorders in maturity thereby attempting to defeat Nature's provision for the survival of the fittest? Over how many decades may a given population continue to boast of a death rate of 12 to 15 per thousand if the mathematical absurdities involved are to be judged in the light of human experience?

The current generation of health publicists, while admitting that a life saved in youth must of necessity cease from some cause in later years, may preach that disorders of age are or

should be as preventable as those of youth, but it will take at least the next generation to preach the hope that humans need never die at all.

The tendencies which prompt such hypotheses should be susceptible of demonstration through very interesting studies of mortality rates in definite age groups for special diseases of the registration area published by the Vital Statistics Division of the United States Census, which constitute "another story" and are not practicable in this paper.

The 10,000 to 70,000 males, aged 16 to 64 years, in the United States Navy and Marine Corps throughout 45 years are conceded to be all too few upon which to base any dogmatic conclusions in this direction, yet the verdict of "not yet proved" which haunts the minds of some has prompted a study of the navy's morbidity statistics to demonstrate a tendency to confirm or deny the impressions already stated as loosely thought facts. The tabulation will occupy several weeks of spare hours and one hopes that, whatever tendency may be declared in the result, it will possess some value and not be in vain.

If it be granted that an unbiased analysis of the movement of so called degenerative diseases among the naval personnel appointed and recruited from all geographical sections of the nation's civil population would be worth while, the first step must be to determine what classes and entities of disease merit inclusion and what factoral value shall be assigned to cases, invalidings, and deaths.

During the present troublous times a writer has to exhibit proof of his neutrality, and then anyone but himself may still question it. One can confess to such preconceptions based upon personal experience as the positive correlation of neuro psychic hypertension and glycosuria, dental caries and appendicitis which have been rather discredited by his own analyses of naval morbidity statistics; one feels quite indifferent to the result, if any, of the present compilation, being determined to perpetrate the paper anyway to stimulate possibly some other doubter to a more profitable investigation.

The use of statistics inductively to prove a theory would not be unique, but it is herein conscientiously denied.

Unfortunately one must make pretension to close familiarity

with naval morbidity data, their inherent and special defects as well as those common to the medical profession and vital statistics at large; for this reason one must decline to defend in detail, which would require many pages, his selection of diseases and methods of determining comparative loss rates.

Pursuant to the foregoing preamble the incidence, invaliding and death rates for 5 classes of scleroses have been plotted (Plate I) for the Navy and Marine Corps for the years 1871 to 1914 inclusive. Although 15 curves upon the same sheet may promote confusion it is believed that their composite represents more intelligently the movement of these diseases than would the resultants obtained by their combination; particularly will widely divergent accidental movements be declared for explanation without reflecting discredit upon steady tendencies.

Most of the titles selected for tabulation for 45 years have been arbitrarily grouped as follows; the only mathematical device utilized, and this really of negligible consequence, is the assumption during certain years that any patient deserting or going on leave represented half the loss of an actual invaliding from the service and has been computed as such:

(1) CIRCULATORY SCLEROSES.

Aneurysm	Intercerebral hemorrhage
Angina pectoris	Valvular disease, heart
Apoplexy	Varix
Arterial sclerosis	Myocarditis
Acute cardiac dilatation	Rupture of heart
Chronic cardiac dilatation	Cardiac hypertrophy
Embolism	Cordis inhibitio
Acute endocarditis	Cordis adiposum
Chronic endocarditis	Degeneratis cordis
Epidural hemorrhage	Atheroma

Paralysis cordis

(2) MALIGNANT PROLIFERATIVE SCLEROSES.

Carcinoma	Epithelioma
Sarcoma	Malignant hypertrophy of prostate

(3) PULMONARY SCLEROSES.

Asthma	Emphysema

Chronic bronchitis

(4) VISCERAL SCLEROSES.

Diabetes insipidus	Uraemia
Diabetes mellitus	Haematuria (non specific)
Gout, acute and chronic	Ascites
Gastric ulcer	Haematomesis
Prostatitis (non infective)	Albuminuria
Nephritis, acute and chronic	Hydrops
Lithaemia	Anasarca

Bright's disease

(5) NEURO-SCLEROSES.

Dementia	Monoplegia
Dementia paralytica	Paralysis agitans
Dementia precox	Sclerosis lateral
Hemiplegia (non traumatic)	Sclerosis posterior
Locomotor ataxia	Multiple sclerosis
Paraplegia	Acute ascending paralysis
Sclerosis disseminated	Cirrhosis cerebri
Amyotrophic lateral sclerosis	Senility

Syringomyelia

The chart conveys the first impression (a) that there was a sharp rise in nearly all rates in 1879; (b) that incidence rates have since tended to fall consistently except for the circulatory scleroses (organic cardiac and valvular disease) during the last 20 years; (c) that during certain years there have been wide fluctations in pulmonary and circulatory diseases; (d) that mortality rates have not fluctuated as widely as have incidence or even invaliding rates; (e) that during the last 20 years upwards of two thirds of the cases of circulatory and neuro scleroses have been invalided so that case invalidity and case mortality have risen decidedly which either is no credit to the clinician or reflects upon the diagnostics of earlier times. The opinion is ventured that the coefficient of unreliability of naval vital statistics would probably be proportional to the remoteness of decades with the maximum error prior to 1879 when decided improvement in collection and compilation occured; invalidings were first classified in published reports in 1879.

Any high rate for 1903 "is undoubtedly due to the large number of recruits admitted to the service during the year" according to the report of the Surgeon General covering that

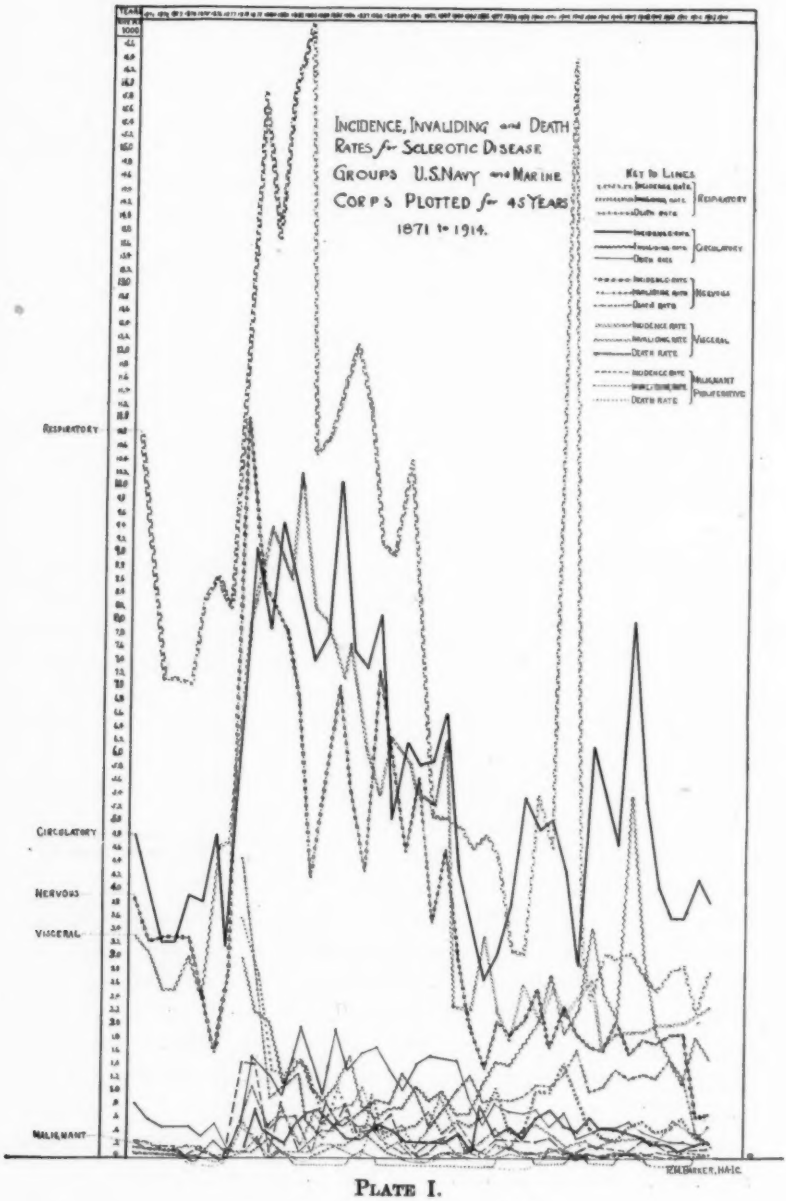

INCIDENCE, INVALIDING and DEATH RATES for SCLEROTIC DISEASE GROUPS U.S.NAVY and MARINE CORPS PLOTTED for 45 YEARS 1871 to 1914.
KEY TO LINES.
RESPIRATORY
CIRCULATORY
NERVOUS
VISCERAL
MALIGNANT PROLIFERATIVE
DEATH RATE
YEARS
RESPIRATORY
CIRCULATORY
NERVOUS
VISCERAL
MALIGNANT
W.M.BARKER, M.A.I.C.

PLATE I.

year. There were accepted 15 per cent. more enlisted men in 1903 than during 1902 and with a lower percentage of rejections than formerly on account of necessarily rapid work of travelling recruiting parties which enrolled nearly one half of the men, practically all recruits, and accepted 59.5 per cent. as contrasted with 53.7 per cent. for the previous year. There were 556 cases of "chronic bronchitis" during 1903 which, as compared with 103 the year before and 86 the year following, accounts for the high rate; this was a diagnosis frequently made in recruits with chronic cough whom it was not policy to retain long enough in the service to determine the underlying cause.

The rise in incidence and invaliding rates for circulatory scleroses in 1905 and 1908 is similarly explained being largely accounted for by recruits with "chronic valvular heart disease," who should never have been accepted. There is, nevertheless, in spite of explanations of variable recruiting influence, a perceptible resultant tendency for circulatory rates to rise and this closely parallels the curve for admissions for syphilis which gradually rose to 27.18 per thousand in 1911 and have since declined to 19.84; for present purposes one is more concerned with the sequelae of venereal diseases than their incidence and the fact that the invaliding rate for all venereal disease has declined steadily from 4.28 per thousand in 1909 to 1.71 in 1914 may be assumed to account for the current decline in rates for circulatory scleroses.

Subject to the conditions indicated in the first part of this paper and to the qualification that small numbers produce rather sharp fluctuations, one concludes that degenerative diseases in the United States Navy and Marine Corps have decreased during the past four decades and to the extent that these data may be considered to reflect the movement of cancer, paralysis, nephritis, and chronic heart, vascular, and pulmonary diseases (except tuberculosis) among the general population there is sufficient indication of similar decreases to justify withholding the prevalent assumption that these diseases are tending to increase until more scientific precision can be obtained in general morbidity statistics.

FLORENCE NIGHTINGALE AS STATISTICIAN.

By Edwin W. Kopf.

The somewhat legendary accounts of this remarkable woman contain but few references to that part of her life and work which should appeal to the students of the history of modern social statistics. More or less is understood of her radical innovations in the nursing care of the sick in institutions and especially in military hospitals; a definite idea exists of her capacities as reformer, administrator, and nurse. Comparatively little is known of her, however, as a constructive compiler and interpreter of descriptive social statistics. One biographer alone, Sir Edward T. Cook, speaks with sympathy and understanding of her as a statistician. He calls her a "passionate statistician."*

The activities of Miss Nightingale in statistics may be classed under several broad categories. We may think of her in terms of her forty years of thought and achievement in the Indian question; in safeguarding the health of the British soldier; in reorganizing civil and military hospital administration at home and abroad; and, in this latter regard, of her pioneer services to the profession of nursing. Her keen intellect, applied to these major projects of her career, comprehended the utility of the statistical method as a means of developing a basis of established fact for social reform.

In early life, Miss Nightingale showed peculiar aptitude for collecting and methodically recording current historical facts. Her observations during the travels of the Nightingales in Europe over the period 1837–1839 are a curious mixture of comment and criticism on the then existing laws, land systems, social conditions, and benevolent institutions. Throughout her life she collected an immense number of pamphlets, reports, and returns which she skillfully analyzed with telling effect in her campaigns for hospital and sanitary reform. Following her nursing apprenticeship with the Fliedners at

*The writer is indebted to Sir Edward T. Cook's "Life of Florence Nightingale" for abstracts from Miss Nightingale's private papers, and for much of the material in this paper.

Kaiserswerth, she undertook further training at the *Maison de la Providence* in Paris; here she proceeded to collect hospital reports, returns, statistical forms, and general information on hospital construction and sanitation. Among her papers then were elaborately tabulated analyses of hospital organizations and nursing systems and their end results. These inquiries extended to both France and Germany. She seems also to have addressed circulars of inquiry on the same subjects to representative hospitals in the United Kingdom.

Miss Nightingale was profoundly influenced by the works of Adolphe Quetelet, the Belgian astronomer, meteorologist, and statistician. Perhaps her practice of methodically recording the facts of her botanical researches led her to one of Quetelet's laws of flowering plants. The common lilac flowers, he averred, when the sum of the squares of the mean daily temperatures, counted from the end of the frosts, equals 4264° centigrade. While this "law" delighted her, she regarded it as a lesser example of Quetelet's researches and statistical conclusions. She was fascinated most by Quetelet's "*Sur l'Homme et le Développement de ses Facultés,*" published in 1835, in which he outlined his conception of statistical method as applied to the life of man. From Quetelet, Miss Nightingale learned much of the science and art which describes human society in terms of numbers. From him she learned the methods, general aims, and results of qualified inquiry into social facts and forces.

MILITARY AND SANITARY STATISTICS OF THE CRIMEAN WAR.

The discipline of Quetelet's new science of social inquiry was to have its first influence upon the military and sanitary statistics of the Crimean War. Miss Nightingale found the medical records of the Scutari hospitals in lamentable condition. Even the number of deaths was not accurately recorded. The three separate registers then maintained gave each a totally different account of the deaths among the military forces. None of the statistical records was kept in uniform manner. She was able to introduce an orderly plan of recording the principal sickness and mortality data of the military hospital establishments which came within the sphere of her influence.

Miss Nightingale's experience in the Crimea filled her with an ardent desire to remedy the scandalous neglect of sanitary precautions in the Army; her study of the available data convinced her that the greater number of deaths in hospitals need not have occurred at all. During the first seven months of the Crimean campaign, a mortality of 60 per cent. per annum from disease alone occurred, a rate of mortality which exceeded even that of the Great Plague in London, and a higher ratio than the case mortality of cholera. Miss Nightingale's vigorous use of these facts resulted in a series of reforms, which in turn reduced this terrible rate of mortality. She observed, also, that if sanitary neglect prevailed in the Army afield, it probably affected the Army at home in considerable degree likewise. She compared the mortality in civil life with the mortality in army barracks. Between the ages of 25 and 35 she found that the mortality among soldiers was nearly double that in civil life. In writing to Sir John McNeill she said: "it is as criminal to have a mortality of 17, 19, and 20 per thousand in the Line, Artillery and Guards, when that in civil life is only 11 per 1,000, as it would be to take 1,100 men out upon Salisbury Plain and shoot them."

Her further observations on the Chatham military hospitals were: "This disgraceful state of our Chatham Hospitals is only one more symptom of a system, which, in the Crimea, put to death 16,000 men—the finest experiment modern history has seen upon a large scale, viz., as to what given number may be put to death at will by the sole agency of bad food and bad air." Among her private notes of 1856 her biographer found this: "I stand at the altar of the murdered men, and while I live, I fight their cause." The one weapon upon which she placed most dependence was her collection of sanitary statistics.

HEALTH, EFFICIENCY, AND HOSPITAL ADMINISTRATION OF THE BRITISH ARMY.

The results of her personal studies of army medical statistics were embodied in a report, from the first intended as a confidential communication to the War Office and the Army Medical Department. There had been considerable delay in

the formation of the Royal Commission on the health of the Army which she had requested in her November, 1856, interview with Lord Panmure. The Royal Warrant establishing the Commission was not issued until May 5, 1857. During this exasperating period of delay Miss Nightingale held in reserve her array of statistics, until, having begun her agitation with the sovereign and continuing through the politicians, she was almost ready to plead her cause with the people. In three months from the day the Royal Warrant was issued, the Commission presented its report. In the meantime, Lord Panmure had asked Miss Nightingale for her "Notes Affecting the Health, Efficiency and Hospital Administration of the British Army." These notes are the least known of her works, because they were never officially published. It has never become known how much of the final Report of the Royal Commission was actually the work of Miss Nightingale. Printed at her private expense and circulated among influential people, her "Notes" made a profound impression. They have been termed "a treasury of authentic fact . . . affording a complete elucidation of the causes which had brought about failure, and showing the means by which the country could best hope to safeguard the truly sacred task of providing for the health of its troops in future wars." Another of her friends who read the proof said: "It has so much the character of good, sincere, enlightened conversation on a subject which is thoroughly understood and appreciated, and so little the appearance of having been 'got up' or of pretension of any kind, literary or artistic." Another reader said: "I regard it as a gift to the Army, and to the country altogether priceless."

The preface to the Notes gave the keynote. Hospitals were shown to be but part of wider programs involving the general health and efficiency of the Army. This was emphasized by the fact that those who fell before Sebastopol by disease were above seven times the number who fell by the enemy. The introductory chapter gave the history of the health of the British Armies in previous campaigns. Six of the twenty sections of the Notes dealt with the medical history of the Crimean War. Two other sections discussed the mortality

of armies in peace and war and the necessity for a statistical department of the army. There were also numerous appendices, supplementary notes, and graphic illustrations and diagrams.

PIONEER IN GRAPHIC ILLUSTRATION OF STATISTICS.

It must be remembered that these Notes were written by Miss Nightingale in the short space of six months, and while in delicate health. In the preparation of her report she had but little assistance; the gathering of the data was facilitated, however, by the friendly coöperation of many broadminded men in the public service. Dr. Farr, for instance, aided materially in the preparation of the comparisons between the mortality of civil and army life and in editing the graphical illustrations which he especially commended. These graphical diagrams were at that time somewhat of an innovation in statistics, and had no significant precedent save in the statistical works of A. M. Guerry, a contemporary of Quetelet. The Report of the Commission, containing some thirty-three written answers by Miss Nightingale to leading questions by the Commission, together with her original tabulation of the appalling morbidity and mortality statistics of the British Army, was issued to the public in January, 1858. The graphical illustrations in her own Notes portrayed, by means of shaded or colored squares, circles and wedges, (1) the deaths due to preventable causes in the hospitals during the Crimean War and (2) the rate of mortality in the British Army at home. "Our soldiers enlist," as she put it, "to death in the barracks." She reprinted this graphic section and distributed it, with a brief memorandum, to leading members of Parliament and to medical and commanding officers throughout the country, in India, and in the Colonies. "It is our flank march upon the enemy," she said.

STATISTICAL DEPARTMENT OF BRITISH ARMY FOUNDED.

The chief product of the Commission's work of interest from the statistical standpoint was the report of the subcommittee on Army Medical Statistics. This committee, consisting of Mr. Sidney Herbert, Sir A. Tulloch, and Dr. Farr, reported

in June, 1858, and published its "First Annual Statistical Report on the Health of the Army" in March, 1861. The compilations were directed by Dr. Thomas Graham Balfour, under whose leadership British army statistics became the best and most useful obtainable in Europe.

The facts published in the "Notes" did not go unchallenged. A pamphlet appeared anonymously calling them in question. Miss Nightingale immediately prepared a reply. This second note was entitled "A Contribution to the Sanitary History of the British Army during the late War with Russia," and constituted a scathing and eloquent account of the preventable mortality which she had witnessed in the East. The graphic charts of the "Notes" were reproduced.

CONSTRUCTION, ORGANIZATION, AND MANAGEMENT OF CIVIL HOSPITALS.

The opposition to the recommendations of the subcommission on Army Barracks stimulated Miss Nightingale to prepare a more extended discussion of hospital construction, organization, and management. From her extensive experience in and study of hospital systems in Germany, France, and Ireland and in the Crimea, she prepared two addresses on hospital construction and sanitation for the Liverpool meeting of the National Association for the Promotion of Social Science. These papers were reprinted as "Notes on Hospitals." These "Notes" in three editions, the last in 1863, revolutionized ideas of hospital construction.

It was pointed out that the hospital statistics then available gave little information of real value on the proportion of recoveries, of deaths, and the average duration of hospital treatment for different diseases, duly qualified by sex and age. A common agreement on the number and nature of statistical data to be tabulated was recommended. A unique feature of this Liverpool address was a mortality table for hospital nurses and attendants showing the greatly increased prevalence of communicable diseases among this class of hospital employees, as compared with the mortality from the same causes in civil life. The deplorable existence of "hospital gangrene" and "hospital septicemia" in that day of defective hospital

sanitation and construction was effectively portrayed by these mortality statistics.

A brief inquiry into the precedent circumstances will be of interest. When Miss Nightingale returned from the Crimea she directed much thought and attention to hospital statistics as an adjunct to administration of institutions for the care of the sick. She found a complete lack of scientific coördination. The statistics were not kept along uniform lines. Each hospital followed its own nomenclature and classification of diseases. The available data had never been tabulated upon forms which would render the statistics of one hospital comparable with those of another. The data had little value for advancing medical knowledge or as an adjunct to hospital management. With the assistance of Dr. Farr, and of other friendly physicians, she drew up a standard list of diseases (largely a selection from the d'Espine-Farr System) and a set of model hospital statistical forms. She had her model forms printed in 1859 and persuaded some of the London hospitals to adopt them experimentally. She and Dr. Farr studied the tabulated results, which had sufficient value to show how large a field of qualified statistical inquiry had been opened by the introduction of her forms.

Miss Nightingale's skill in so effectively employing the statistical method in army sanitary reform had led to her election, in 1858, to fellowship in the Royal Statistical Society. On October 16, 1874, the American Statistical Association elected her an honorary member. A photographic reproduction of her letter of acceptance appears on the following page.

INTERNATIONAL STATISTICAL CONGRESS OF 1860.

This growing association with the leaders of thought in the statistical world of her time enabled her to take an active part in drawing up the program of the second section of the International Statistical Congress, held at London in 1860. This Section dealt with sanitary statistics. Miss Nightingale and Dr. Farr incorporated the forms for uniform hospital statistics, which had been experimentally introduced into a group of London hospitals in 1859, in a paper read for her before the Section by Dr. McMillian. Additions and recommendations,

London Jan.y 30 1875

Sir

I request that you will be good enough & thank the American Statistical Association in my name for the honour which they have done me in electing me an Honorary Member & to assure them that I am ever their faithful servant

Florence Nightingale

I trust that I may be allowed to send a Blue Book, being the last "Annual Sanitary Report" of the India Office: & a pamphlet: "Life or Death in India" by myself: as a small contribution to their Library.

F.N.

To the Corresponding Sec.y

chiefly by Dr. Berg of Sweden and Dr. Neumann of Berlin, were concurred in by the author in a letter to the Earl of Shaftesbury, President of the Section.

This paper on uniform classifications and forms for hospital statistics was afterward widely circulated among physicians and hospital officials. Large quantities of the forms were supplied to hospitals in various parts of the country. The Paris hospitals took up the plan. Guy's Hospital, London, prepared a statistical analysis of its experience for the years 1854 to 1861; St. Thomas' for the years 1857 to 1860; and St. Bartholomew's, for 1860. At a meeting held at Guy's Hospital on June 21, 1861, it was unanimously agreed to adopt a uniform plan of registration, that each hospital should publish its own statistics annually, and that the forms devised by Miss Nightingale should be used so far as practicable.

ELEMENTS OF HOSPITAL MEDICAL STATISTICS.

Miss Nightingale then prepared the detailed paper on "Hospital Statistics and Hospital Plans" for the Dublin meeting of the National Association for the Promotion of Social Science in 1861. In this paper she emphasized the seven primary tabulation elements of hospital sickness statistics, which were:

(1) Number of patients remaining in hospital on first day of year.

(2) Patients admitted during year.

(3) Patients recovered or relieved during the year.

(4) Patients discharged as incurable, unrelieved, for irregularities or at own request.

(5) Patients died during year.

(6) Patients remaining at end of year.

(7) Mean duration of cases in days and fractions of a day.

These tabulation "elements" were to be compiled as seven separate tables, each showing diseases classified thereunder by sex and age (by single years under five and by five year periods thereafter). The additional consideration of diseases contracted in hospital while under treatment was also provided for. These extensions of the original paper were suggested by Drs. Berg and Neumann. Miss Nightingale held that these supplementary tables would bring out the fact of the then

scandalous prevalence of "hospital diseases" such as gangrene and septicemia.

The statistics of the various hospitals adopting her forms were published in the *Journal* of the Royal Statistical Society for September, 1862. Miss Nightingale's system of uniform hospital statistics was never generally successful over any considerable period of time. The plan, but partly realized in the requirements of the King's Hospital Fund, demands for its complete and effective operation a more intelligent appreciation of and a finer enthusiasm for statistical facts than is afforded even by present day voluntary and competitive hospital systems in metropolitan districts.

A further example of Miss Nightingale's use of the statistical method in hospital economy was her study of the questions relating to the possible removal of St. Thomas' Hospital at the instance of the Southeastern Railway. The railway company proposed the removal of the hospital to provide for an extension of the right-of-way from London Bridge to Charing Cross. She analysed the origins of cases served by the hospital, tabulated the proportions of cases within certain radial distances, and showed the probable effect upon patients of the removal of the hospital to the several possible sites suggested. This method of fitting hospital accommodation to the needs of populations has only recently been revived. It represents a legitimate application of demographic principles to the study of the relief of dire human needs.

The statistics of surgical operations from the standpoint of hospital cost and practical end results were next considered by Miss Nightingale. In a commentary on St. Bartholomew's statistical report, Miss Nightingale outlined the minimum requirements of a report form for the nature and result of surgical operations. The subject was further developed in a paper read for her before the Berlin meeting of the International Statistical Congress in 1863.

Before the close of the London meeting of the International Statistical Congress, 1860, Miss Nightingale addressed a letter to Lord Shaftesbury. The letter was read to the whole Congress and adopted by it as a resolution. The resolution impressed upon governments the prime necessity for publishing

more extensive and numerous abstracts of the statistical information in their possession.

MISS NIGHTINGALE AND THE CENSUS OF ENGLAND, 1861.

Miss Nightingale made a determined effort to extend the scope and application of the Census of 1861, largely in the direction of collecting statistics which would serve as a foundation for sanitary reform. Her aim was twofold: one was to enumerate the sick and infirm on Census Day. To those who denied that it could be accomplished, she pointed out that it had been done elsewhere, notably in Ireland. Her second ambition was to obtain complete data on the housing of the population; this, too, had been practicable in Ireland, she urged. In pressing her point with the Census officials she said: "The connection between the *health* and the *dwellings* of the population is one of the most important that exists. The 'diseases' can be approximated also. In all the more important—such as smallpox, fevers, measles, heart disease, etc. —all those which affect the *national* health, there will be very little error. Where there *is* error in these things, the error is uniform . . . and corrects itself. . . . " These few remarks still serve as prolegomena to any future census plans for England or any other country.

The Census Bill came up late in the session and not much comment can be found on the foregoing suggestion for a development of Census inquiry. The only critical comment made in the debate proceeded from Lord Ellenborough, who, far from considering the innovations of sickness and housing statistics, proposed to exclude most of the inquiries already suggested. Miss Nightingale, in her conception of census methods and results, was far ahead of her day and generation. Subsequent censuses, chiefly in the United States, in Tasmania, and in one or two other countries, have included sickness and housing inquiries.

SCOPE AND USE OF STATISTICS.

Miss Nightingale's activities in furthering statistical progress were the outgrowth of her deep conviction, variously expressed in her several papers, that the social and moral

sciences are in method and substance statistical sciences. In her several papers on metaphysical topics, she asserts that statistics were to her almost a religious exercise. Her conception of theology was that its true function was to ascertain the "character of God." Statistics, she mused, discovered and codified law in the social sphere and thereby revealed certain aspects of "the character of God." Doubtless, in these speculations she was profoundly influenced by the studies of Quetelet in moral statistics, as typified in his "*Recherches statistiques sur le Royaume de Pays-Bas.*"

Statistics as an element in political education also appealed with peculiar force to Miss Nightingale. In a letter to Benjamin Jowett she said: "The Cabinet Ministers, the army of their subordinates . . . have for the most part received a university education, but no education in statistical method. We legislate without knowing what we are doing. The War Office has some of the finest statistics in the world. What comes of them? Little or nothing. Why? Because the Heads do not know how to make anything of them. Our Indian statistics are really better than those of England. Of these no use is made in administration. What we want is not so much (or at least not at present) an accumulation of facts, as to teach men who are to govern the country the use of statistical facts."

She proposed a number of leading questions which she desired to see investigated by the statistical method: What had been the result of twenty years of compulsory education? What is the effect of town life on offspring in number and in health? What are the contributions of the several social classes to the population of the next generation? In proposing these inquiries she anticipated by more than a generation the work of the eugenists and biometricians of the Galton-Pearson school. Her friend, Adolphe Quetelet, had inaugurated studies of this character. Both he and Dr. Farr had hoped that she would pursue her inquiries more extensively. In conversation with Benjamin Jowett she proposed to found at Oxford a Professorship or Lectureship in Applied Statistics. Mr. Jowett seems to have discussed the matter with Mr. Arthur Balfour and Professor Alfred Marshall. Miss Night-

ingale, on her part, consulted Mr. Francis Galton, who responded earnestly and worked out a detailed plan. There was more or less discussion over the matter, but in the press of other affairs, the proposition was discarded. It is certainly of very great interest in this connection to observe that many years afterward such an enterprise was undertaken by the University College in London; probably, however, not directly issuing from Miss Nightingale's suggestion.

VITALITY OF ABORIGINAL RACES.

Following her disquisitions on army, medical, and civil hospital statistics, came her statistical investigations into colonial questions: the first into the vitality of native or aboriginal races in the Colonies; the second into the sanitary condition and material welfare of the population and military establishment of India. In a paper before the National Association for the Promotion of Social Science, meeting at Edinburgh in 1863, she discussed the gradual disappearance of the native races when brought into contact with the influences of civilization. The paper was suggested by Sir George Grey, who, at that time, was deeply engaged with questions of Colonial policy. The preliminary inquiry related to the probable effect of European school usages and school education generally, upon the health of children, of parents, and of races which had not heretofore been brought under any system of education. With the assistance of the Duke of Newcastle, she prepared a form which was sent by the Colonial office to the governors of the various colonies. From the returns of 143 schools she deduced the mortality of school children by age period and by sex, and further classified the statistics by causes of death. A second inquiry into the statistics of colonial hospitals gave important information on the causes of high institutional mortality among the native races. The numbers involved were small, and the results were necessarily considerably in error; but, in the main, the conclusions as to the neglect of sanitary precautions and the change in the living habits of native races were sound.

A further paper on the aboriginal races in Australia was read before the same Association at York, England, in 1864. This

essay contained copious quotations from correspondence with colonial governors over points raised by the first paper. The Colonial Office circulated the reprint of the Edinburgh paper widely. Miss Nightingale has been considered a pioneer in work for arresting the decline of native races, so far as such work has been possible.

BRITISH ARMY IN INDIA.

After the death of Sidney Herbert, Miss Nightingale devoted the larger portion of her time and attention to the Indian question. Her earlier years of service to the British Army at home were not more significant than her later years of endeavor for the army and people in India. The greater proportion of the lives of soldiers lost in India was not chargeable to battle, but to disease caused by insanitation and general ignorance of military tropical hygiene. In 1859, it was found that the average annual death rate of the British armies in India had been 69 per 1,000 since the year 1817.* In recent times the figure has been 5 per 1,000. The changes in living and working accommodations which brought about this reduction in army mortality are directly traceable to the recommendations of the Royal Commission, appointed in 1859, which reported in 1863. An unrecorded fact, however, is that Miss Nightingale's suggestion led directly to the appointment of the Commission and that the greater part of the Report was her handiwork. The suggestions upon which permanent reforms in army sanitation in India were based were also her work.†

For eight months, during the latter part of 1858 and the earlier part of 1859, Miss Nightingale importuned Lord Stanley for the appointment of a Royal Sanitary Commission which would do for the armies in India what had been done for the armies at home. She had contemplated for two years before,

* While this figure included battle casualties of the campaigns of the forty years ending with 1856, the mortality figure was still excessive. It was stated that the registered mortality among British troops in India was six times that of Englishmen of the same ages at home. Again, in an earlier investigation into mortality from disease among troops in the East Indies (including for the most part British India) death rates varying from 40 to 98 per 1,000 of mean strength over the period 1840–1848 were found.

† British soldiers in India today live in barracks which surpass in comfort and sanitation any that can be found in other countries. Every regiment, battery, and depot has its regimental institute, a sort of soldiers' club, library, reading and recreation room, a temperance association, and a theatre. The use of alcoholic beverages is discouraged and every encouragement is given to useful employment for the men.

the appointment of a Commission to investigate the entire question of the armies in British India. The mutiny of almost the whole of the Bengal native army and the contingents in northern India in 1857, which had filled the minds of the British population with thoughts of vengeance and repression against the native army, had only served to fix her attention upon sanitary and other administrative reform on behalf of the soldiers. Her analysis of the statistics of army mortality in India convinced her that there was murder committed not by the Sepoys alone. To her mind, it was murder to doom British soldiers to death by neglect of the most elementary sanitary precautions.

Anticipating the appointment of the Commission, she began collecting, tabulating, and interpreting data she derived from circulars of inquiry which she had drafted and sent to all the stations in India. The inquiry form lacked little in requisite completeness and precision of detail. In the meantime, Miss Nightingale and Dr. Farr searched the sickness and mortality records of the India Office.

The report of the Indian Sanitary Commission when issued in 1863 comprised in all 2,028 pages, mostly in small print. The greater part of the statistical work in the Report bore clear evidence of Miss Nightingale's influence. Her inquiry blank, in the first instance, provided the vehicle for the transmission of much of the evidence. The replies to her questions occupy the whole of the second volume of the Report. In October, 1861, the Commission requested her to submit her interpretation of these Stational Reports. Her observations upon these reports occupied 23 pages and are the most remarkable of her published works. Her unusual treatment of the subject by the addition of illustrative wood-cuts describing Indian hospitals and barracks, made the Treasury demur, however, at the cost, but Miss Nightingale was permitted to pay for the printing out of her private purse. Copies of these observations were sent to the queen and to influential members of the government. Sir John McNeill wrote: "The picture is terrible, but it is all true. There is no one statement from beginning to end that I feel disposed to question and there are many which my own observation and experience enable me to con-

firm." In detail, her notes related to the camp diseases which follow the selection of poor sites, defective disposal of human wastes, overcrowding in barracks, lack of suitable occupation and exercise, dietaries and defective hospital arrangements. The sources of statistical data for the armies in India were also criticised. In addition to her observations, Miss Nightingale prepared with Dr. Sutherland an abstract of the returns upon which her "Observations" were founded.

Moreover, when the Report was published she moved with her characteristic decision to secure for it the newspaper and periodical publicity which it deserved. She contributed a popular résumé of the Royal Commission's Report to the National Association for the Promotion of Social Science, meeting at Edinburgh in 1863, entitled "How People may Live and not Die in India." The paper was republished in 1864, with a preface and an account of what the Commission had actually achieved in sanitary works and measures. In 1868, the Secretary of State printed her résumé of the Indian Sanitary Question from 1859 to 1867 and her memorandum of advice and suggestions on the entire situation as it then stood. The dispatch from Sir Stafford Northcote under date of April 23, 1863 (drafted by Miss Nightingale), was printed at the same time. This dispatch resulted in the first of the annual series of Indian Sanitary Reports. In the reports for 1868 and 1869 appear two of Miss Nightingale's contributions; in the first an Introduction of eight pages and in the second her paper on "Sanitary Progress in India."

Her statistical enterprises of this period are well summarized in a few phrases which are here quoted from one of her letters: "I am all in the arithmetical line now . . . I find that every year . . . there are in the Home Army, 729 men alive every year who would have been dead but for Sidney Herbert's measures, and 5,184 men always on active duty who would have been 'constantly sick in bed.' In India the difference is still more striking. Taken on the last two years, the death rate of Bombay is lower than that of London,* the healthiest city in Europe. And the death rate of Calcutta is lower than that of Liverpool and Manchester. But this is not

*These figures related only to conditions prevailing at the time this letter was written.

the greatest victory. The Municipal Commissioner of Bombay writes that the 'huddled native masses clamorously invoke the aid of the Health Department if but one death from cholera occurs; whereas formerly half of them might be swept away and the other half think it all right.'"

In 1873, the National Association for the Promotion of Social Science invited her to contribute a paper on the ten years of progress in India since her "How People may Live and not Die in India" paper appeared. Her title for this later paper was "How some People have Lived and Not Died in India." The India Office reprinted the paper in its 1874 bluebook. The salient fact developed in this report was that the death rate in the Indian Army had been reduced from 69 per 1,000 to 18 per 1,000. This summary of ten years of sanitary progress in India she was qualified to prepare in consequence of her editorial work on the annuals issued by the sanitary department of the India Office.

In 1877, Miss Nightingale published two letters on famine in India and followed these by an article in the *Nineteenth Century* magazine. This article, "The People in India," gave the principal facts about the Indian famines and proceeded further to describe in considerable detail the evils of usury in the Bombay Deccan. Beginning with 1874, Miss Nightingale collected statistics of irrigation in India, and of the effect of irrigation on the life and health of the people. These data, the appendix of the second part of an unpublished work on the Indian Land Question and Irrigation Systems, were afterward partially used in several isolated papers. She thought much on education in India. There had been a neglect of elementary education. The exception was found in the system of village schools established by Lieutenant-Governor James Thomason, of what is now the Agra Province. The report of the Indian Education Commission of 1883 directed attention to the essential difficulties residing in the language, credal, race, and traditional differences of the populations of the several provinces. The two chief difficulties in the way of a diffusion of education among the masses in India are the large agricultural population, among whom it is in all countries difficult to advance any system of education, and the existence

of a hereditary class, whose object has been to maintain their monoply of learning as the chief buttress of their social supremacy. Questions such as these occupied Miss Nightingale's attention in the years 1881 and 1882.

The succeeding years were taken up in turn by Army Hospital Service reform, district nursing organization, nursing education and Indian finance problems.

In 1891 Miss Nightingale finally laid aside her ambition to found at Oxford a Professorship in Applied Statistics. This relinquishment of active interest in the progress of statistics was indicative only of her failing physical powers. The gradual failure of sight, memory, and mental apprehension proceeded during the last fifteen years of her life. Her death occurred on August 13, 1910.

FLORENCE NIGHTINGALE AS STATISTICIAN.

Florence Nightingale may well be assigned a position in the history of social statistics next to those occupied by Quetelet and Farr. Her ardent, genuine sympathy for the sick and distressed was greatly augmented by a positive genius for marshalling definite knowledge of the forces which make for disease and suffering. The same intellect which sharply separated the formulae, procedures, and practical methods of nursing from its abiding principles as one of the humanities, also discerned the statistical facts of sickness and other forms of disharmony between the individual and his environment. In hospital care of the sick, as an instance, Miss Nightingale replaced the astigmatic case viewpoint with one embodying a grasp of total situations. This is one function of statistics.

Her earnest perception of this truth—an essential in the equipment of the statistician—was firmly supported by her control over laborious detail and by her scrupulous care in testing the statistical foundations of her premises. The interpretations she placed upon the facts developed in her researches show a careful regard for the competent counsel which she so often consulted. In all these respects Miss Nightingale exhibited the prime qualities of one thoroughly versed in the art of preparing and reflectively analysing social data.

CONSUMPTION OF GAS AS AFFECTED BY POPULATION.*

By G. P. Watkins and L. H. Lubarsky.

The relation between population and the amount of use of transportation facilities has often been made a subject of statistical investigation. As regards street railways, in particular, it has been claimed that the number of passengers varies as the square of the population of the cities served. This hypothesis, as thus mathematically expressed, is questionable, but there can be no doubt that there is a rough functional relation between the population of a city or cities and the number of street railway rides, and that the increase of the latter is much more than in direct proportion to the increase of the former. If the choice is between mere proportional variation and the quadratic relation, the latter is much nearer the truth.†

The possibility of a similar relation between agglomeration (and, in a somewhat loose sense, density) of population and the extent to which the services of other public service enterprises are availed of is worthy of investigation, though the others are not so easily dealt with as the street railways. In the case of water supply the method of distributing the cost accords more with principles of taxation than with those of market price-making. The competition between electricity and gas—as regards use and consumption, if not always commercially—which is facilitated by the overlapping of the means of service, causes difficulties in the case of these utilities. It would be desirable to deal with light, heat, and power as separate services rendered the consumer, instead of with gas supply and electricity supply, thus avoiding the complication due to the substitution of electricity for gas. The present study is subject to an important limitation on this account.

*The general division line between the work of the joint authors of this paper is: economic and statistical analysis mainly by Watkins, and graphic construction and analysis mainly by Lubarsky.

†For a discussion of this question by the writer of the above paragraph, see the Annual Report of the New York Public Service Commission for the First District for 1910, Vol. III, pp. 22–53; also a qualification of the conclusion in the similar report for 1912, Vol. II, p. 109, including the footnote.

In all these cases, there is the dynamic as well as the static aspect of the situation to be considered. The latter viewpoint relates to two or more cities of different size compared for the same date; the former relates to the same city at different times with regard to intervening growth of population. Time and progress enter greatly into the dynamic kind of comparison and but little into the static. The interest of the sort of study in question is at least as much dynamic as static. But the way to obtain an indication of the importance of the former element is to determine and make allowance for the importance of the latter, since even where time brings in other and possibly more important influences, mere population magnitude is a factor. Hence the two aspects of the general problem need to be studied together. It is too often assumed that there is a constant relation between population and consumption, or that the only cause of change in per capita consumption is a change in price. This assumption does not hold for urban public utilities, though it may sometimes be well enough, pragmatically speaking, to assume constancy of consumption, apart from price changes, for short periods of time.

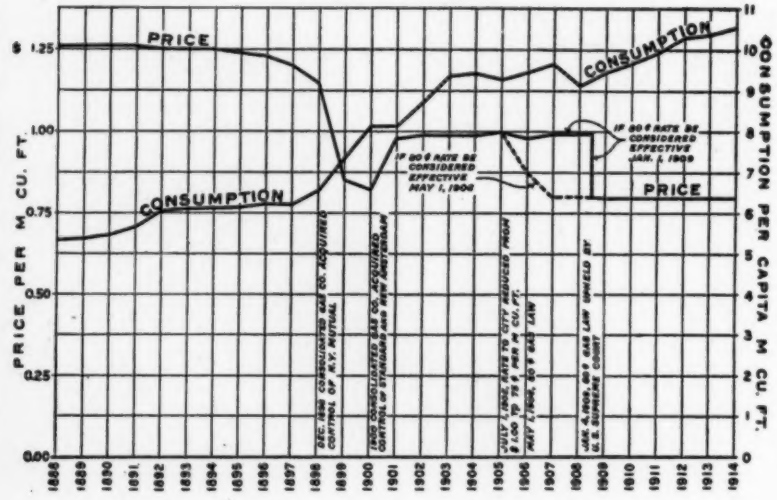
In the case of gas supply, it would be quite easy to attribute to differences in population results that are actually due to price differences, since the price per thousand itself bears in a general way a functual relation to the size of cities. Companies serving larger cities can usually afford to supply gas at lower rates. The lower price is, of course, a reciprocal effect of density of demand (larger per capita consumption) and of consequent "increasing returns," so that differences of the kind in question need not be dismissed as simply due to differences in price. But allowance needs to be made for this factor, that is, for the stimulating effect of a lower price upon consumption. The nearly uniform nickel street railway fare from place to place as well as from time to time in the United States is an important statistical advantage that is wanting in the case of the study of other utilities.

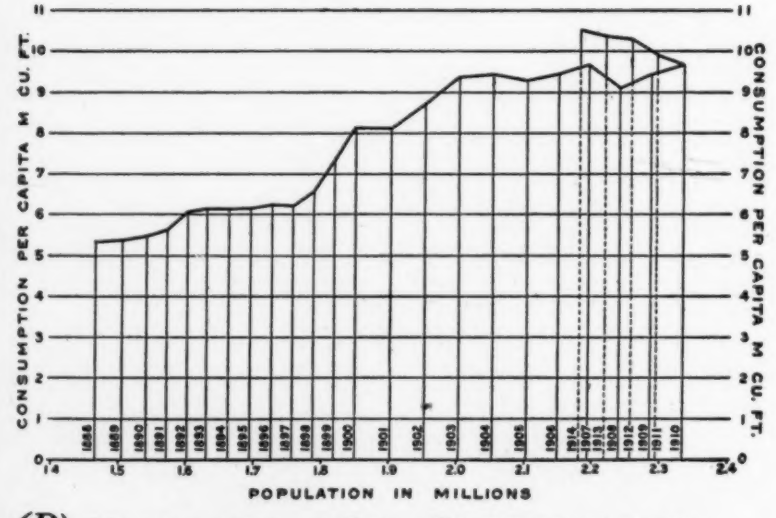
A dynamic factor of some independent interest is an increasing standard of living. The city dweller has doubtless considerably raised his standard in the past generation, at least as regards degree of per capita use of public utilities. As

DIAGRAM I

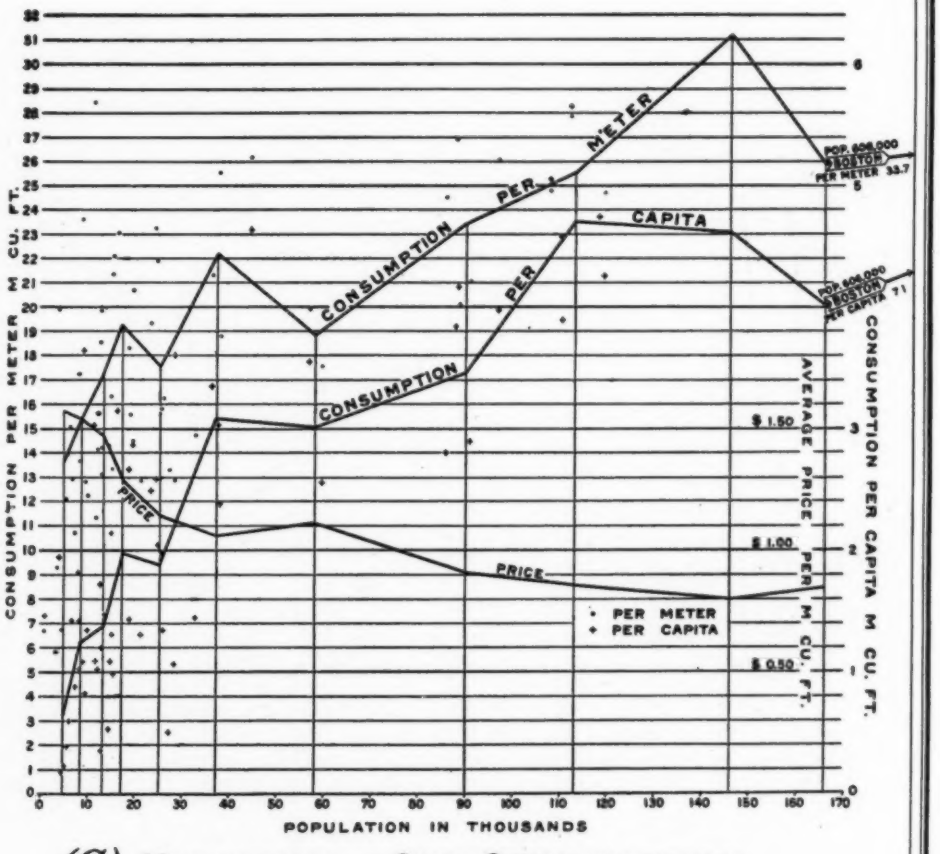
CONSUMPTION OF GAS
IN RELATION TO
POPULATION

(A) GROWTH OF GAS CONSUMPTION PER CAPITA AND AVERAGE PRICE
MANHATTAN BOROUGH, NEW YORK CITY
1888 - 1914


PRICE
CONSUMPTION
CONSUMPTION
PRICE
IF 80 ¢ RATE BE CONSIDERED EFFECTIVE MAY 1, 1900
IF 80 ¢ RATE BE CONSIDERED EFFECTIVE JAN. 1, 1909
DEC. 1898 CONSOLIDATED GAS CO. ACQUIRED CONTROL OF N.Y. MUTUAL
1900 CONSOLIDATED GAS CO. ACQUIRED CONTROL OF STANDARD AND NEW AMSTERDAM
JULY 1, 1905, 80 ¢ RATE EFFECTIVE FROM
MAY 1, 1906, 75 ¢ RATE EFFECTIVE FROM
JAN. 4, 1909, NY GAS LAMP UNITED AS
U.S. SUPREME COURT
PRICE PER M CU. FT.
CONSUMPTION PER CAPITA M CU. FT.



(B) VARIATION OF GAS CONSUMPTION WITH POPULATION IN VARIOUS YEARS
MANHATTAN BOROUGH



(C) VARIATION OF GAS CONSUMPTION WITH POPULATION IN VARIOUS LOCALITIES
MASSACHUSETTS, 1910

regards gas consumption, it should be noted that the higher standard often means the substitution of electricity for gas as an illuminant, and, on the other hand, of gas for coal in cooking and to some extent in other heat uses.

How much greater is gas consumption per consumer or per capita in a community having a large population than in one having a small population, is the subject of the present statistical investigation. The question is dealt with by the graphic method on the basis of such data as are available. The accompanying diagram which consists of three sub-diagrams, lettered A, B, and C, serves to determine how far per capita consumption is a function of varying population.

Sub-diagram A, the one in the upper left-hand quarter of the plate, shows primarily the growth in per capita consumption of gas in the Borough of Manhattan, City of New York, from 1888 to 1914. As the price of gas plays an important part in influencing consumption, another curve showing the average price per M cu. ft. for the same period is also shown in this sub-diagram. Sub-diagram B, in the lower left-hand section of the plate, utilizes the same data, but the consumption figures are geometrically coördinated with homologous populations. Both these sub-diagrams relate to the same urban territory, the variation in population and consumption depending on time.

The data for sub-diagram C have no relation to those for the other two. It shows that at the same point of time, the consumption of gas both per capita and per meter in different localities varies with the population of the locality. There is also an average price curve, which shows that price varies inversely as population; but the price variation is not as great as the variation of consumption. The data relate to localities in Massachusetts for 1910. The fact that, for gas consumption, figures of more recent date might be used is of little importance compared with the necessity of estimating corresponding populations that would accompany their use.* While serving mainly for comparison with and corroboration of results for New York City, the difference in the nature of the

*The data of the present article were put into shape and the diagram constructed before 1915 figures were available.

comparison should be noted. These Massachusetts figures are not directly affected by progressive changes with time—in other words, they show an economically static relation—while the New York City results may be due as much to the passage of time as to differences in population magnitudes—in other words, they are presumably dynamic in character.

The data used in the diagram are shown in the accompanying tables. The data of Table I are of independent interest. Those of Table II are of interest chiefly in connection with the diagram and therefore only such details are given as relate directly to the diagram and make it possible to identify the absolute numbers taken from the Massachusetts report. A detailed description of each sub-diagram together with a statement of its statistical significance follows the tables.

In connection with the population data of Table I, there is occasion to mention the probable deficiency of the 1890 federal enumeration of New York City with reference to its possible effect on the curves of the first two sub-diagrams. As is mentioned in a footnote to the table, allowance is made for this condition by arbitrarily increasing the Census figure for Manhattan Borough in 1890 by 100,000. According to the method employed to estimate population between decennial years the effect of any under or over estimation in the figure used is spread through the entire decade from 1890 to 1900 as well as before, and allowance could easily be made for it by the eye if occasion required.

As regards the Massachusetts localities, also, a qualification with reference to the population data is necessary. The population served by a particular gas company should strictly be, for comparative purposes, the number of inhabitants within reach of its mains. But population data of that nature are seldom to be had; nor does it make much difference if in the case of cities of medium or large size the territory taken in is determined by civil boundaries. In the case of small cities and towns some allowance for the effect of including people not within reach of the mains is necessary. Especially in Massachusetts, where the form of town government is such as to make the transition to organization as a city of little significance, the distinction between rural areas and areas

whose population is incorporated as villages and cities, is scarcely applicable, the town government being adequate for many urban functions and the city, when organized, being territorially coextensive with its predecessor town. In fact the United States Census classifies the population of Massachusetts towns as urban or rural merely according to the number of inhabitants a town contains, the significance of an "incorporated place" being applicable in the ordinary sense only outside of New England. Hence the population of the smaller Massachusetts localities used in connection with this table may be misrepresentatively large in proportion to the number of inhabitants in position to be served by the gas companies.

The data for sub-diagram A are the two columns of derivative numbers of Table I. A few historical facts, having possible bearing on the direction of the curves at particular times, are noted at appropriate places on the diagram. The construction of the two curves needs little comment. As regards the price curve from 1905 to 1908, some explanation is necessary. On May 1, 1906, the price of gas for private consumers in the greater part of New York City was fixed at 80 cents per M cu. ft. by an act of the legislature passed the winter before. The gas companies operating in Manhattan took the matter to the courts and, pending a decision, the companies were allowed to charge the consumers $1.00 per M cu. ft., but the 20 cents excess was to be returned to the consumer if the 80 Cent Gas Law was held to be constitutional. On January 4, 1909, the United States Supreme Court upheld the law in question and the gas companies proceeded to refund the excess charge. Under these circumstances, there is room for question as to just what price should be compared with consumption per capita, but the preference should doubtless be given to the higher price, with a qualification. Both averages are shown in the price curve, the full line representing the price actually paid. The abrupt drop at the beginning of 1909 shows the change in the rate actually paid. The dotted curve between 1905 and 1909 shows the average price if the law be considered effective on May 1, 1906.

The curve of consumption per capita shows an almost steady

upward tendency. The average consumption has practically doubled since 1888. The variations or increases from 1888 to 1897 were slight. From 1897 to 1903 there was a rapid increase of about 3 M cu. ft. This marked increase is explained by the great reduction in the average price of gas. There was a slight falling off in consumption per capita in 1908, reflecting the after effects of the 1907 panic. Since then the per capita consumption has been steadily rising, due largely to the final reduction in price to 80 cents.

The price curve shows a decrease of more than one third since the earliest year represented in the diagram. From 1898 to 1900 there appears to have been lively competition, which is reflected by the drop in the price from about $1.15 in 1898 to 82 cents in 1900. In 1901 the average price became about $1 per M and it remained there until the 80 Cent Gas Law became effective in 1909. But the effect of the reduction upon per capita consumption extends several years beyond this. From 1909 the price to the public has been constant, but per capita consumption has continued to move upwards. Throughout the period covered by the diagram the growth of the use of gas for industrial purposes and for cooking has doubtless been a factor in increasing per capita consumption.

Irregularities in the growth of population not reflected in the estimates used affect the detailed course of the curve considerably. It is probable that population increased less rapidly in 1913 and 1914 than in 1910-12. A slight peak appearing in 1907, also the salient angle at 1892 may be due to increases in population which the method of estimation of this element cannot well take account of.

Sub-diagram B is the graphic presentation of the same facts on a different plan. Of the coördinates of the series of points plotted, the abscissae represent particular populations, and the ordinates, corresponding per capita consumption. The scale for population is thus along the horizontal axis, and that for consumption along the vertical axis. Both axes have the same point of origin, which, however, is not shown on the diagram, since only the part of the space between the portion of the axes in question that contains the points plotted is significant. The population points for each year are located

on the horizontal axis, and at each of them ordinates are drawn which are numerically proportional to the per capita consumption in each year. The population of the intercensal years having been determined as an arithmetic series, the intervals on the axis of abscissae between census figures are equal. So far as known, the maximum population was reached in 1910, the 1915 State Census figures for Manhattan Borough being considerably less than those for 1910.* Hence the ordinates for 1911, 1912, 1913 and 1914 recede instead of advance, and are therefore distinguished as dotted lines. The curve connecting the extremities of the ordinates chronologically reflects the direct movement of population until 1910, and the retrograde movement from 1910 to 1914. This curve is the same as the consumption curve of the first sub-diagram, only the yearly intervals are variable instead of being constant, and the ordinates advance as long as population increases and recede when population decreases.

The steady increase in per capita consumption is seen as before. But it is further shown that from 1910 on, although the population decreased, per capita consumption continued to increase. Hence per capita consumption cannot be said to be simply a function of population magnitude. It is influenced by factors apart from those directly affecting the growth of population in the territory served. The business and amusement district of Greater New York would naturally be indirectly favored by population growth occurring outside the borough that contains the most important of such interests. The rising standard of living would be similarly effective. It should be noted that from the point of view of judging of the general direction of the per capita curve as related to the growth of population, the second sub-diagram serves the purpose better than the first, since the slope of the curve changes as the rate of increase of population changes, with the exception, of course, of such irregularities as cannot be recognized in interpolating between census years. The slope is more nearly uniform in this curve than in the one above, though the effect of price changes is still marked.

*The state enumeration of 1915 was probably deficient for New York City; nevertheless there appears to have been an actual decrease in the population of Manhattan Borough.

Sub-diagram C is based on Table II. The population figures are as of April 15, 1910, the meters as of June 30, 1910, and the metered gas as of the two year period from July 1, 1909, to June 30, 1911. By taking the average per year of metered gas for the two years, a figure is obtained that synchronizes with the date of the number of meters. The slight divergence of the population date is not important, especially for urban population.

The method of plotting the third sub-diagram is similar to that for the second. The horizontal axis denotes population and the vertical consumption per meter and per capita, also price per M cu. ft. The coördinates of each point plotted as a dot are the population and per meter consumption for a particular locality, and of those plotted as plus signs, population and per capita consumption. Hence there are a dot and a plus sign on every ordinate. To eliminate the irregularities resulting from the large number of small localities, the latter have been grouped as shown in part B of Table II, averages for population and for per meter and per capita consumption having been computed by groups. The average points for each of these various groups together with the points for the two large localities having populations of 165,900 and 146,000, respectively, are connected, giving the two curves of consumption per meter and consumption per capita, respectively. The largest locality is that served by the Boston Consolidated Gas, with 606,000 population, an average per meter consumption of 33.7, and an average per capita consumption of 7.1, the price being 80 cents per M. Owing to a limitation of the graphic method, it is impossible to locate these points on the diagram as drawn. The character of the curves as they would be extended beyond the right edge of the diagram is, however, indicated by arrows. The coördinates of the smaller localities are properly plotted individually, but the points are not connected.

As a necessary qualification of the significance of the other curves a price curve is added. The average price per M cu. ft. for each locality is given in the table, but only the average price for each group is plotted. In computing these average prices, sales to other gas companies have been eliminated.

The degree of certainty of the significance of the data would be greater if prices were constant. But with the aid of the price curve, allowance can be made for such differences. Differences in per capita consumption between large and small localities are doubtless partly due to the fact that it is in general the smaller communities that have the higher rates. But allowance for the price factor appears to leave a difference still to be accounted for by other factors, whose comparative importance will be considered presently.

There is much irregularity in the variation of per meter and per capita consumption with the size of population aggregates. But, as already indicated, the general trend is unquestionably towards increased consumption both per meter and per capita with increased population. For reasons already mentioned, less importance should be attached to the points and lines for localities under 20,000 population than to those for the larger localities. The small number of the cities in each group is also a reason why considerable irregularity above this population magnitude is to be expected.

The slope of the per capita curve in sub-diagram C is of course not directly comparable with that of the curve in sub-diagram B. According to the trends of these two curves as roughly determined from the two sub-diagrams an increase of population in the same locality (Manhattan) of about 13 per cent. is accompanied by an increase of 50 per cent. in per capita gas consumption, while a relative difference in population between two separate localities for the same date must be 500 per cent. of the smaller population in order to correlate with a difference of 50 per cent. in per capita gas consumption. Of course such a comparison must be very rough. And it must be qualified with reference to price differences. The 50 per cent. increase in per capita gas consumption in Manhattan is accompanied by a 36 per cent. decrease in price. The 50 per cent. difference in per capita gas consumption among the Massachusetts localities is accompanied by about the same 36 per cent. difference in price. If we could attribute the whole difference in consumption to differences in price, assuming also that these rough quantitative inferences are sufficiently correct, then the demand curve for gas might

be alleged to be a "constant outlay" curve, a one third decrease in price per unit being responded to by a one half increase in consumption, the aggregate price thus remaining the same. As to the relation between price and consumption the data would perhaps repay mathematical analysis by way of correlation coefficients.

From this result it might be inferred that price accounts for all the differences and changes in consumption. But for such a conclusion the comparison proves too much. It negates the influence of the dynamic as well as the static factors. The former certainly appear to count for something in the Manhattan curves. And as regards the static (Massachusetts) curves, while there is evidently a close inverse correlation between price and consumption, yet between 90,000 and 600,000 population, where there is the smallest range of variation in group average prices (10 cents) there is the greatest range in per capita consumption, that is, from 3.5 to 7.1.

Apart from the question of the influence of price, it is clear that dynamic factors are far more important than the mere size of the population aggregate. As a matter of fact, it is quite proper to class price among the dynamic factors, but it was the intention of the present study to abstract from the effect of price changes and price differences so far as possible. And there seems to be some ground for believing that mere aggregation of population does tend to increase gas consumption somewhat. The complexity of the problem is such that an attempt to specify how much is hardly warranted. And it may be necessary to conclude, at the same time, that the public appears to be able quickly to obtain for itself most of the benefit of density of consumption by means of a lower price, thus obscuring the effect upon consumption of agglomeration of population as such.

TABLE I.

POPULATION, SALES OF METERED GAS, AND REVENUE DERIVED THEREFROM, BOROUGH OF MANHATTAN, CITY OF NEW YORK, 1888–1914.

Year Ending Dec. 31.	Population. (a)	Sales of Gas (M cu. ft.) (b).	Sales per Capita. (M cu. ft.).	Revenue from Sale of Gas.	Average Price per M cu. ft.
1888	1,465,908	7,797,147	5.32	$9,824,405	$1.260
1889	1,503,562	8,075,509	5.37	10,175,141	1.260
1890	1,541,216	8,409,343	5.46	10,595,772	1.260
1891	1,572,104	8,819,804	5.61	11,122,953	1.261
1892	1,602,991	9,681,954	6.04	12,102,442	1.250
1893	1,633,879	9,979,014	6.11	12,473,767	1.250
1894	1,664,766	10,181,325	6.12	12,726,656	1.250
1895	1,695,654	10,402,830	6.13	12,899,509	1.240
1896	1,726,541	10,742,799	6.22	13,213,643	1.230
1897	1,757,429	10,900,965	6.20	13,081,158	1.200
1898	1,788,317	11,661,300	6.52	13,410,495	1.150
1899	1,819,205	12,325,943	7.33	11,327,052	.850
1900	1,850,093	15,036,787	8.13	12,330,165	.820
1901	1,900,660	15,476,533	8.14	15,167,008	.980
1902	1,951,227	17,004,702	8.71	16,834,655	.990
1903	2,001,794	18,725,618	9.35	18,538,362	.990
1904	2,052,361	19,415,818	9.46	19,221,659	.990
1905	2,102,928	19,540,243	9.29	19,540,243	1.000
1906	2,148,651	20,296,822	9.45	17,690,151 (c) 19,904,915	.872 .981
1907	2,194,374	21,227,252	9.67	17,003,439 (c) 21,094,699	.801 .994
1908	2,240,096	20,442,298	9.13	16,378,154 (c) 20,341,694	.801 .995
1909	2,285,819	21,656,335	9.47	17,287,177	.798
1910	2,331,542	22,583,176	9.69	18,037,196	.799
1911	2,293,846	22,730,971	9.91	18,154,275	.799
1912	2,256,150	23,247,816	10.30	18,571,457	.799
1913	2,218,454	23,015,070	10.37	18,385,758	.799
1914	2,180,758	22,940,883	10.52	18,322,321	.799
1915	(d) 2,143,061				

(a) Sources: United States Census for decennial years and New York State Census for 1905 and 1915, figures for intervening years being interpolated according to arithmetical progression. But the Census figure for 1890 is increased by 100,000 to allow for deficient enumeration.

(b) Sources: 1888–1905 City's Exhibit No. 46, in the printed record of the case of the *Public Service Commission* vs. *the Consolidated Gas Co.*, Vol. V, p. 5745, also reproduced in William D. Mark's "Finances of Gas and Electric Light and Power Enterprises," opposite p. 398; 1906–1914, company returns furnished to Public Service Commission and its predecessor, the Board of Gas and Electricity. The four gas companies serving Manhattan Borough are the Consolidated, Standard, New York Mutual, and New Amsterdam. For 1907 and 1908 some estimation is necessary in order to put the figures on a calendar year basis.

(c) Includes 20 cents per M cu. ft. paid by the public pending decision of appeal of 80 Cent Gas Law.

(d) The figure for 1915 is preliminary and 5,314 larger than the final reported figure for New York County, but the enumeration appears to be considerably deficient.

TABLE II.

POPULATION, SALES OF METERED GAS TO CONSUMERS AND NUMBER OF METERS, FOR CERTAIN LOCALITIES IN MASSACHUSETTS, 1910.(a)

(A) SIGNIFICANT DATA FOR EACH LOCALITY.

Population of Territory Served (thousands).	Number of Meters.	Average Price per M cu. ft. (b)	Average Consumption per Meter.	Average Consumption per Capita.
606.4	128,170	$ .80	33.68	7.119
165.9	26,560	.854	25.92	4.149
146.0	21,626	.806	31.21	4.624
119.3	20,540	.845	24.71	4.255
118.5	20,577	.927	27.23	4.728
112.1	23,413	.780	27.24	5.688
110.2	18,763	.905	22.81	3.885
107.7	21,771	.871	24.80	5.015
96.7	14,841	.857	26.01	3.994
90.9	12,542	.876	21.01	2.898
88.4	18,347	.979	20.04	4.157
88.0	12,517	.94	26.99	3.838
85.9	9,793	.867	24.57	2.801
59.4	8,620	1.11	17.55	2.546
56.9	10,107	1.11	19.99	3.552
44.1	7,815	.931	26.21	4.644
37.8	4,793	1.14	18.81	2.383
37.5	4,444	.987	25.57	3.031
35.7	5,616	1.14	21.31	3.353
32.6	3,501	1.43	14.76	1.448
28.4	2,349	1.19	12.87	1.066
28.4	5,642	1.36	18.08	3.598
27.4	1,048	1.00	13.26	0.507
26.0	2,135	1.65	16.23	1.331
25.4	3,202	1.28	15.82	1.994
24.8	2,316	1.04	21.91	2.047
24.4	2,721	1.10	23.26	2.594
23.2	2,990	1.00	19.37	2.493
21.3	2,135	1.50	12.96	1.297
19.4	2,725	1.24	20.68	2.900
19.0	1,728	1.48	15.57	1.418
18.7	2,726	1.17	18.24	2.666
16.2	2,210	1.20	23.05	3.141
15.3	711	1.40	21.26	0.988
15.2	903	1.40	22.12	1.310
15.1	1,231	1.59	13.34	1.086
14.9	1,950	1.39	16.33	2.131
14.7	541	2.09	14.38	0.529
13.1	968	1.53	19.88	1.472
13.0	1,104	1.14	14.20	1.203
12.9	1,208	1.51	18.50	1.726
12.9	354	1.79	13.12	0.360
12.1	856	1.79	14.27	1.006
11.6	1,119	1.63	11.25	1.090
11.3	1,197	1.30	28.69	3.038
9.9	1,092	1.56	12.31	1.363
9.4	594	1.62	12.88	0.813
8.8	530	1.31	18.23	1.101
8.5	384	1.55	23.63	1.063
8.5	863	1.61	13.83	1.400
8.0	840	1.57	17.26	1.809
6.7	740	1.54	12.95	1.422
5.8	230	1.92	15.03	0.598
5.6	160	1.29	13.91	0.394
5.1	98	1.72	12.10	0.232
4.9	140	2.15	6.70	0.191
3.7	361	1.15	19.96	1.943
3.0	365	2.07	9.35	1.152
1.1	230	2.92	6.73	1.429

(a) Board of Gas & Electric Light Commissioners of the Commonwealth of Massachusetts, 1911, pp. 96, 241[a], 222[a]. Acetylene gas companies are not included.

(b) Prices are for 1911 and are computed by using data on p. 226[a] in conjunction with p. 229[a].

(B) SUMMARY FOR ALL DATA BY GROUPS OF LOCALITIES.

Size Class of Locality thousands).	Number of Localities (a) in Class.	Aggregate Population April 15, 1910.	Average Population for Each Class.	Average Price per M cu. ft.	Number of Meters June 30, 1910.	Consumption per Year (Average of 1910 and 1911) (M cu. ft.).	Consumption per Meter (M cu. ft.).	Consumption per Capita (M cu. ft.).
....	1	606,369	606,369	$ .80	128,170	316,518	33.68	7.119
....	1	165,924	165,924	.854	26,560	688,400	25.92	4.149
....	1	145,986	145,986	.806	21,626	675,045	31.21	4.624
120–100	5	567,772	113,554	.862	105,064	2,673,587	25.45	4.709
100– 80	5	449,974	89,995	.907	68,040	1,595,679	23.45	3.546
60– 50	2	116,296	58,148	1.11	18,727	353,292	18.87	3.038
45– 30	5	187,765	37,553	1.06	26,169	580,021	22.16	3.089
30– 20	9	229,294	25,477	1.14	24,538	431,016	17.58	1.880
20– 15	7	118,945	16,992	1.29	12,234	235,425	19.24	1.979
15– 10	9	116,603	12,956	1.47	9,297	160,690	17.28	1.378
10– 6	7	59,861	8,552	1.54	5,043	75,837	15.04	1.267
6– 2	6	28,125	4,688	1.57	1,354	18,423	13.60	0.655
Under 2(b)	1	1,084	1,084	2.92	230	1,548	6.73	1.429

(a) "Locality" means territory served by a particular company so far as population returns permit of such a division or combination of data. The population figures are from the Federal Census as used by the Massachusetts Board.

(b) Not used in plotting the curves.

INTERPOLATION OF ORDINATES AND AREAS AMONG AREAS.

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Ordinary interpolation consists geometrically of adding one or more ordinates in a systematic manner to a given series of ordinates. The intervals which separate the given ordinates may be equal or unequal.

Ideal interpolation requires that a large number of the given ordinates shall be used to determine the value of the ordinate or ordinates to be interpolated in order that whatever sense of uniformity exists between the values of the given ordinates shall be maintained after the interpolation. The degree of reliability of the given ordinates will usually decide roughly how many of them should be used to give appropriate results.

The purpose of this paper is to derive a formula to be used to interpolate *areas* as well as ordinates among *areas* in as direct and systematic a manner as ordinary interpolation is and has been performed; however, the areas or ordinates to be interpolated are parts of the given areas and the given areas must be contiguous and of equal breadth.

The use of such a formula can be best explained by a concrete illustration, and the best illustration is to be found in connection with mortality or population statistics, especially the latter because of the great difficulty encountered in attempting to gather such statistics for individual ages. The tendency of human beings to state their ages in figures ending with a "5" or more often a "0" leads to such concentration of data at such ages as to render the results worthless in the form collected. For this reason such statistics are now usually collected in age groups of 5, 10, or some other number of years and then whenever the values for the individual ages are desired they are obtained by interpolation. The method of interpolation used in the past has been very indirect, involving considerable transformation of the data previously. Other

problems will readily suggest themselves when once the purpose of the formula is clear.

To illustrate then, suppose the population of a community to be given by the following hypothetical age groups:

Ages.	Population.
10–14	362
15–19	586
20–24	938

If we should then draw a curve in such a way that ordinates dropped at equal intervals would enclose areas which would correspond to the populations given above and in the same order these areas might be thought of as being made up of similar areas which would correspond to the populations for the individual ages. Thus the formula or formulas to be derived may be used to determine either the populations corresponding to individual ages (ordinates) or for any group of ages (areas) which is a fractional part of one of the original groups.

The derivation and application of the formulas to be derived are based upon the calculus of finite differences; however, the theory involved in the application is so simple that anyone can apply the formulas by simply following the examples given in the paper.

If we define the two functions $u_{\underline{x}}$ and $y_{\underline{x}}$ by the relation

$$\Delta y_{\underline{x}} = u_{\underline{x}} = y_{\underline{x+1}} - y_{\underline{x}},$$

whence
$$y_{\underline{x}} = \sum_{x=0}^{x-1} u_{\underline{x}} + y_{\underline{0}} = u_{\underline{0}} + u_{\underline{1}} + \ldots + u_{\underline{x-1}} + y_{\underline{0}} \qquad (1)$$

and if we expand $y_{\underline{x+1}}$ and $y_{\underline{x}}$ by the so called Newton's formula in terms of $y_{\underline{0}} (= y_0)$ and its differences, where

$$y_{\underline{x}} = y_0 + \frac{x}{t}\Delta y_0 + \frac{x(x-t)}{t^2}\frac{\Delta^2 y_0}{2!} + \frac{x(x-t)(x-2t)}{t^3}\frac{\Delta^3 y_0}{3!} + \ldots$$

and

$$y_{\underline{x+1}} = y_0 + \frac{x+1}{t}\Delta y_0 + \frac{(x+1)(x+1-t)}{t^2}\frac{\Delta^2 y_0}{2!} + \frac{(x+1)(x+1-t)(x+1-2t)}{t^3}\frac{\Delta^3 y_0}{3!} + \ldots$$

we may write

$$u_{\underline{x}}{}_{\underline{i}} = \frac{\Delta y_0}{t} + \Delta F^{(2)}(x,t)\frac{\Delta^2 y_0}{t^2 2!} + \Delta F^{(3)}(x,t)\frac{\Delta^3 y_0}{t^3 3!} + \ldots \qquad (2)$$

where $F^{(2)}(x,t)$ refers to the factorial so often found in connection with finite differences and equals $x(x-t)$

$$F^{(3)}(x,t) = x(x-t)(x-2t)$$

etc.

If we let

$$A = x$$
$$B = x-t$$
$$C = x-2t$$

etc.,

then

$$\Delta F^{(2)}(x,t) = A+B+1$$
$$\Delta F^{(3)}(x,t) = AB+AC+BC+A+B+C+1$$

etc.

Formula (2) is the fundamental formula desired but the various terms on the right hand side may be shown to have significant interpretations and meanings.

If we define $w^{x}_{t} = u_{\underline{x}}{}_{\underline{i}} + u_{\underline{x+1}}{}_{\underline{t}} + \ldots + u_{\underline{x+t-1}}{}_{\underline{t}}$

then, by (1),

$$y_0 = y_0$$
$$u_{\underline{0}}{}_{\underline{i}} + u_{\underline{1}}{}_{\underline{i}} \ldots + u_{\underline{t-1}}{}_{\underline{t}} + y_0 = y_{\underline{t}}{}_{\underline{i}} = y_1 = w_0 + y_0$$
$$u_{\underline{0}}{}_{\underline{i}} + u_{\underline{1}}{}_{\underline{i}} \ldots + u_{\underline{2t-1}}{}_{\underline{t}} + y_0 = y_{\underline{2t}}{}_{\underline{i}} = y_2 = w_0 + w_1 + y_0$$
$$y_3 = w_0 + w_1 + w_2 + y_0$$

etc.

Hence

$$\Delta y_0 = y_1 - y_0 = w_0$$
$$\Delta y_1 = y_2 - y_1 = w_1$$

and

$$\Delta^2 y_0 = \Delta y_1 - \Delta y_0 = \Delta w_0$$

Likewise

$$\Delta^3 y_0 = \Delta^2 w_0$$
$$\Delta^4 y_0 = \Delta^3 w_0$$

etc.,

and (2) may be written

$$u_{\underline{x}}{}_{\underline{i}} = \frac{w_0}{t} + \Delta F^{(2)}(x,t)\frac{\Delta w_0}{t^2 2!} + \Delta F^{(3)}(x,t)\frac{\Delta^2 w_0}{t^3 3!} + \ldots \qquad (3)$$

where it is easy to show that

$$\overset{(2)}{\Delta F}(x,t) = 2x - t + 1$$

$$\overset{(3)}{\Delta F}(x,t) = 3x^2 + 3x(1-2t) + (1-3t+2t^2)$$

$$\overset{(4)}{\Delta F}(x,t) = 4x^3 + 6x^2(1-3t) + 2x(2-9t+11t^2) + (1-6t+11t^2-6t^3)$$

etc.

Now, the values w_0, w_1, w_2 . . . are obviously groups of t values, just as we find in mortality and population statistics, and $u_{\frac{x}{t}}$ represents one of these values included in a group, its identification depending upon the value of x. As an illustration let us take the illustration given at the beginning of this paper. Here $t=5$, and $u_{\frac{0}{5}}$, $u_{\frac{1}{5}}$, etc., represent the populations at ages 10, 11, etc., and $u_{\frac{0}{t}} + u_{\frac{1}{5}} + \ldots + u_{\frac{4}{5}} = w_0 = 362$, etc.

Thus

$$\begin{array}{lll} w_0 = 362 & & \\ & \Delta w_0 = 224 & \\ w_1 = 586 & & \Delta^2 w_0 = 128 \\ & \Delta w_1 = 352 & \\ w_2 = 938 & & \end{array}$$

and the population at age, say 15, according to (3) is

$$\begin{aligned} u_{\frac{5}{5}} &= \frac{w_0}{5} + 3\frac{\Delta w_0}{25} - 4\frac{\Delta^2 w_0}{125} + \qquad \text{to second differences} \\ &= \frac{362}{5} + 3\frac{224}{25} - 4\frac{128}{125} + \\ &= 95.184 \text{ or } 95 \end{aligned}$$

Since population and deaths are usually given in quinquennial age groups t usually has the value "5." In this case (3) may be written

$$u_{\frac{x}{5}} = .2w_0 + .04(x-2)\Delta w_0 + .004(x^2-9x+12)\Delta^2 w_0 + .0008(x^3-21x^2+116x-126)\frac{\Delta^3 w_0}{3}$$

$$+ .00004(x^4-38x^3+467x^2-2014x+1915.2)\frac{\Delta^4 w_0}{3} + \ldots \quad (4)$$

although we believe it is rarely necessary to use differences beyond the second in such a connection. Of course, in case

the formula is needed to only a lower number of differences, the higher differences of the formula are simply ignored.

If x be given the value "7," formula (4) up to and including second differences becomes identical with a formula used by Mr. George King in his method of constructing abridged mortality tables as explained in the report of the English Registrar General for 1914.

So far we have pointed out how formula (3) may be used to determine for example the population for a single age. As a rule, in such a connection, the populations for each and all of the individual ages are desired and in such a case the work may be simplified by using not formula (3) or (4) but the leading term and differences obtained from it when x is given successively the values $\frac{5}{5}, \frac{6}{5} \ldots \frac{10}{5}$ and the results differenced five times. The leading term and differences given in workable form are as follows:

Leading term	$.2w_0+$	$.12\Delta w_0-$	$.032\Delta^2 w_0+$	$.0144\Delta^3 w_0$
1st difference	$.04$ "	$+.008$ "	$-.0064$ "	
2d difference		$.008$ "	$-.0016$ "	
3d difference			$.0016$ "	(A)
4th and higher differences.			0	

As an illustration let us take our original but now somewhat extended problem and break up the population for the age group (15–19) into populations for each and all of the individuals included in the group.

Ages.	Populations.			
10–14	$w_0=362$			
		$\Delta w_0=224$		
15–19	586		$\Delta^2 w_0=128$	
		352		$\Delta^3 w_0=105$
20–24	938		233	
		585		
25–29	1523			

When the leading term and differences (the underscored values) are computed, written as shown, and added successively in the ordinary way, we have the following results (shown with the other values occurring in connection with the addition):

Ages.	Populations.				
15.....	96.696				97
		9.312			
16.....	106.008		.856		106
		10.168		.168	
17.....	116.176		1.024		0 or 116
		11.192		.168	
18.....	127.368		1.192		127
		12.384			
19.....	139.752				140
	586.000				586

In this illustration the work was carried out to an unnecessary number of decimal places in order to show a perfect check on the work. Usually one or two decimals will prove sufficient, depending upon the size of the values involved.

As a general rule mortality and population statistics, even at their best, are faulty and hence in most cases all third differences may be ignored in which case the leading term and differences may be taken as

Leading term	$.2w_0+.12\Delta w_0-.032\Delta^2 w_0$	
1st difference	$.04$ " $+.008$ "	
2d difference	$.008$ "	(A′)
3d and higher differences	0	

It will be noticed that the formulas of leading term and differences given above are applied centrally, *i. e.*, at least one value must be known on each side of the value to be broken up, and hence the formulas can be used in all places except to break up "end" values.

The leading term and differences for breaking up "end" values are obtained by setting $x=\frac{0}{5}, \frac{1}{5}, \ldots \frac{5}{5}$ successively in formula (4) and differencing the results five times and are as follows:

Leading term	$.2w_0-.08\Delta w_0+.048\Delta^2 w_0-.0336\Delta^3 w_0$	
1st difference	$.04$ " $-.032$ " $+.0256$ "	
2d difference	$.008$ " $-.0096$ "	
3d difference	$.0016$ "	(B)
4th and higher differences	0	

Thus, the leading term and differences (B) may be used to break up "end" values such as population "362" for the age group (10–14) given above, as follows. However, in this case, only second differences will be used in order to show clearly how the work is finally performed.

Ages.	Populations.			
10.....	60.624			
		4.864		
11.....	65.488		1.024	
		5.888		0
12.....	71.376		1.024	0
		6.912		0
13.....	78.288		1.024	
		7.936		
14.....	86.224			
	362.000			

Here, again, an unnecessary number of decimal places are carried in order to show a perfect check on the work.

Of course, in breaking up the other of the two "end" values occurring in any set of statistics the column of values needs only to be reversed and the formulas applied in the same way. In all cases any negative signs that appear must be carefully preserved and carried along with the work.

The formulas derived above will prove sufficient to cover practically all cases met with in ordinary work of this kind; but, looked at from a geometrical standpoint, the formulas derived so far can be used to interpolate only what might be regarded as *ordinates* among *areas*. To make our paper anywise complete we should include a formula which would allow us in case of necessity to determine, say the population which would correspond to some fraction of a particular age group such as the first 3/5, or the middle 2/10 and, in fact, any fractional part of any group. Such a formula would then be used to interpolate what might be regarded as *areas*.

To establish a formula for determining the value which would correspond say to any $\frac{n}{t}$ part of a given group, it is

obviously necessary to merely determine the value of the sum.

$$U_{\frac{nx}{t}} = u_{\frac{x}{t}} + u_{\frac{x+1}{t}} + \ \ldots\ + u_{\frac{x+n-1}{t}}$$

in terms of the formula (3), where, to recapitulate, $U_{\frac{nx}{t}}$ gives the value which corresponds to any $\frac{n}{t}$ part of the group with which $\frac{x}{t}$ is connected, where

$\frac{0}{t}, \frac{1}{t} \ \ldots\ \frac{t-1}{t}$ fall in the first group,

$\frac{t}{t}, \frac{t+1}{t} \ \ldots\ \frac{2t-1}{t}$ fall in the second group, etc.

The summation suggested above is so easily performed by finite integration that merely the final result (to second differences) is given, as follows:

$$U_{\frac{nx}{t}} = \frac{nw_0}{t} + A\frac{\Delta w_0}{t^2 2!} + B\frac{\Delta^2 w_0}{t^3 3!} + \ \ldots \qquad (5)$$

where $A = n(2x+n-t)$

$B = n\left\{3x^2+3x(n-2t)+(n-t)(n-2t)\right\}$

etc.

Suppose, as an illustration, we desire to determine the population of the first 3/5 part of the quinquennial group (15–19) of the example given in this paper, using second differences. Here $t=x=5$ and $n=3$, or

$$U_{\frac{nx}{t}} = 3/5 w_0 + 12\frac{\Delta w_0}{25} - 8\frac{\Delta^2 w_0}{125}$$

$$= 316.528 \text{ or } 317$$

which will be found to be the same as the sum of 95.184, 105.168 and 116.176 found separately using second differences.

CHARTERS FOR AMERICAN BUSINESS CORPORATIONS IN THE EIGHTEENTH CENTURY.

By Joseph S. Davis, *Harvard University.*

The corporation was naturalized in America in the seventeenth and eighteenth centuries. In the last half century of the colonial era it was utilized, in scattering instances, for business purposes. Immediately after the Revolution a marked extension of this use was one of the numerous politico-economic experiments essayed. The experiment succeeded. Thereupon a business corporation movement, unprecedented in any country, developed in the last decade of the century. The accompanying statistics, based upon a careful if not exhaustive examination of the compiled and session laws of the various states, are presented to reveal the salient features of this movement.*

In the period concerned no classification of business corporations had developed. The charters are here classified, therefore, on a common sense basis, upon which a few comments are in point. The banks were entirely joint stock commercial institutions. Of the 33 insurance companies, 11 were mutual, for protection against loss by fire; of the 22 stock companies, a few were specifically chartered for fire or marine insurance, but the large majority were privileged to write both kinds of risks, while several charters were broad enough to include life insurance, of which practically none was actually written.† The term "highway companies" is used in preference to "transportation companies," since every company here included engaged merely in constructing and maintaining the basis of communication, not in conducting transportation. No distinction between canal companies and others is made in the group of charters for the improvement of inland navigation; for the precise means used varied with the locality rather than with the companies or charters.

* Judge S. E. Baldwin's essay on "Private Corporations" in *Two Centuries Growth of American Law* (*Yale Bicentennial Series*, New York, 1901) has been the authority on this subject. The present statistics are more complete and somewhat more accurate. Additional data, especially relating to individual companies, will appear in the writer's forthcoming *Essays in the Earlier History of American Corporations.*

† Certain ecclesiastical corporations which provided annuities for superannuated clergy or the widows and orphans of clergymen are not included, since they were not business corporations.

A few charters gave powers to accomplish varied purposes. Thus a turnpike company was entitled to erect a toll bridge; a manufacturing company had the right to dig canals to afford an outlet for its products; a canal company was empowered to build docks and furnish a city water supply; and a water company was authorized to employ its surplus capital as it should see fit. As a rule, however, one of the objects indicated was clearly the principal one, and such companies have been classified according to the dominant purpose. The White River Falls Bridge Company of New Hampshire and Vermont, however, was apparently equally interested in spanning the river and locking its falls: it has, therefore, been listed under two heads, and to this extent there is a double counting.

Furthermore, several corporations received two or more charters. The most notorious example is the Bank of North America, whose congressional charter of 1781 was buttressed by state charters from Massachusetts, New York, and Pennsylvania in 1782 and Delaware in 1786, and effectually supplanted by a new one from Pennsylvania in 1787. Four companies for building bridges over boundary rivers and 8 companies for improving navigation affecting two states secured charters in two jurisdictions. After making allowance for double counting from these various sources, it appears that not more than 317 distinct corporations were authorized by the 335 charters counted.

A few charters may have escaped the writer's eye. In particular it is probable that several water companies secured charters under the Massachusetts general incorporation act of February 21, 1799; but I have been able to find evidence of none. With this exception, the statistics are believed to be reasonably complete.

The tables here given summarize the principal available information. Table I, in its three parts, gives a summary view of the charters granted, grouped by sections, periods, and general purposes. Tables II and III show the progress of the movement year by year, with reference to sources of corporate powers and the specific purposes authorized, and Table IV roughly correlates these last two features without reference to dates of charters. Table V, finally, brings out certain facts

bearing upon the relation of the number of charters to the population in the several states.

Certain characteristics of the movement are evident from a glance at Table I. But 2 per cent. of the eighteenth century charters were granted before the Revolution; 88 per cent. were granted after 1790, and three fifths of these in the last 5 years. The 33 charters granted in 1781–90, moreover, created but 25 distinct corporations. The progress of the movement is further brought out by annual averages for five year periods, as follows:

Period.	Annual Averages.	
	No. of Charters.	No. of Corporations.
1781–1785	2.2	1.2
1786–1790	4.4	3.8
1791–1795	22.6	21.4
1796–1800	35.8	35.2

New England strikingly leads in the number of charters, with 60 per cent. of the total; the others are about equally divided between the Middle and Southern states, if Maryland is counted with the latter. In the decade 1781–90, on the other hand, more charters were granted south of Mason and Dixon's line than north of it; the South shared but slightly in the boom in charter granting after 1790 which so markedly affected New England. The dominant type is clearly the highway companies, which constituted nearly two thirds of the total number; the financial corporations made up 20 per cent., the local public service companies 10, while the business corporations proper added less than 4 per cent. The local public service companies were largely confined to New England, business corporations proper to the New England and Middle states.

The more detailed tables reveal further facts. The years 1791–92 show a rapid increase in new charters. In the single year 1792, more corporations were created than in the entire

decade 1781–90. Except Kentucky and Georgia, all of the states had swung into line by 1792, and only Delaware and South Carolina failed to grant at least one charter in that year. The high point of the period is 1795, due chiefly to New Hampshire's large contribution; from this year on, however, a high level is maintained—from the average of 37 per annum there is no deviation greater than 6. Before 1791 nearly half of the charters, and more than half the corporations chartered, were for the improvement of inland navigation; thereafter there was a fairly wide distribution among different types. Disregarding sporadic or experimental charters, one may date the beginning of the *movements* for various types as follows: 1783, inland navigation; 1790, banking; 1791, toll bridge; 1794, insurance; and 1795, water supply.

In order of ubiquity the inland navigation companies come easily first: of this type every New England, Middle, and Southern state chartered at least one. Toll bridge companies appear in 12 states; banking, insurance, and water companies in 10. The leading states in chartering particular types were: *banking*—Massachusetts, with 7 out of 34; *insurance*—Maryland and Rhode Island, each with 6 out of 33; *inland navigation*—Virginia, with 14 out of 74; *toll bridge*—New Hampshire, with 19 out of 73; *turnpike*—Connecticut, with 23 out of 72; *water supply*—Massachusetts, with 15 out of 32; and *manufacturing*—Massachusetts, with 4 out of 8. North Carolina and Georgia chartered none but navigation companies, Kentucky only a bridge company. The predominating type in Maine and New Hampshire was the toll bridge, in Connecticut and New York the turnpike, in Virginia and South Carolina as well as their sister Southern states (except Maryland), the inland navigation company.

Banking and insurance charters were about equally numerous, though insurance companies slightly outnumbered the banks. Highway companies were about equally divided among the three types,—inland navigation, toll bridge, and turnpike. Water companies constituted nearly the whole of the local public service companies, and were about as numerous as banks or insurance companies. Manufacturing companies, few though they were, constituted 60 per cent. of the business corporations proper.

The leadership of the New England states is emphasized by the detailed tables. Each ranked higher in number of charters than in population in 1800. The story is the same if one compares percentage of charters with percentage of population. Rhode Island, with 1.3 per cent. of the population, granted nearly as many charters as Virginia, with 16.6 per cent. of the population; Connecticut, with 4.7 per cent. of the population, granted more charters than the four states south of Maryland, which contained 35.2 per cent. of the population; Rhode Island and Connecticut together, with 6 per cent. of the population, granted about as many charters as all the Middle or Southern states. For New England as a whole, 16.3 charters were granted per 100,000 population (1800), as compared with figures for the Middle states of 4.6 and the Southern states of 2.9. In this comparison Rhode Island leads with 28.9 charters per 100,000 population, but backwoods Vermont, the lowest New England state, shows a figure of 12.3 to contrast with 6.1 for Maryland. In each section there is an approach to uniformity in density, although in this respect Maryland fits in best with the Middle states.

The New England states also lead in types of charters. All but one of the various types are represented there, and two of its types (mining, land) are not elsewhere represented. In every type but inland navigation companies, in which the South is ahead, it leads. On the average, each New England state chartered 7 types of corporations, each Middle state, 5, each Southern state, 3. Here Connecticut leads, with 11 different types represented.

Mere statistics of charters are, of course, inadequate. We should like further to know how many corporations went actually into operation, what was the mortality experience, how much capital was employed in all and in each group, what were the characteristic sizes, whether they increased or decreased as the movement progressed, and so on. Records still extant throw gleams of light on these subjects, but nothing approaching complete statistics of them can be hoped for. Yet the few figures here shown indicate a breadth and significance of this early corporation movement which has hardly been sufficiently appreciated.

TABLE I.

SUMMARY OF EIGHTEENTH CENTURY CHARTERS TO BUSINESS CORPORATIONS IN THE UNITED STATES, GROUPED BY PERIODS, SOURCES OF CHARTERS, AND GENERAL TYPES.

Sources of Charters	Colonial	1781–85	1786–90	1791–95	1796–1800	Total Charters	*Per Cent.*
United States		1		1		2	*.6*
New England	6	4	4	70	116 (a)	200 (a)	*59.7*
Middle States	1	2	4	22	38	67	*20.0*
Southern States		4	14	22	25	65	*19.4*
Western States					1	1	*.3*
Total Charters	7	11	22	115	180 (a)	335	*100.0*
Per Cent	*2.1*	*3.3*	*6.6*	*34.3*	*53.7*	*100.0*	

General Type	Colonial	1781–85	1786–90	1791–95	1796–1800	Total Charters	*Per Cent.*
Financial	1	5	5	29	27	67	*20.0*
Highway		5	14	79	121	219	*65.4*
Local public service	5			4	27(a)	36(a)	*10.7*
Business (proper)	1	1	3	3	5	13	*3.9*
Total Charters	7	11	22	115	180(a)	335	*100.0*

Sources of Charters	Financial	Highway	Local Public Service	Business (proper)	Total Charters	*Ancillary, additional or Joint Charters*	Total Corporations
United States	2				2		2
New England	33	130	30(a)	8	200(a)	*8*	192
Middle States	16	42	4	5	67	*7*	60
Southern States	16	47	2		65	*3*	62
Western States		1			1		1
Total Charters	67	219	36(a)	13	335	*18*	317
Ancillary, additional, or Joint Charters	*5*	*13*			*18*		
Total corporations	62	206	36(a)	13	317		

(a) Charters to water supply companies issued under the Massachusetts general incorporation act of Feb. 21, 1799, (*Laws*, ed. 1801, ii, 843–847) cannot be found and are not included.

TABLE II.

EIGHTEENTH CENTURY CHARTERS TO BUSINESS CORPORATIONS IN THE UNITED STATES, CLASSIFIED BY YEARS AND SOURCES OF CHARTERS.

Sources of Charters	Colonial	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799	1800	Total	*Per Cent.*
United States		1										1										2	*.6*
Maine(a)												1	1	2	2	3	3	7	2	1	1	23	*6.9*
New Hampshire													6	1	2	10	2	4	1	3	3	32	*9.6*
Vermont												1	1		1	3	1	4		4	5	20	*6.0*
Massachusetts	1		1		1	1		2		1			8	3	3	5	8	8	6	6	6	60	*17.9*
Rhode Island	3											1	2		3	1	1			2	7	20	*6.0*
Connecticut	2				1					1			3			7	3	9	9	2	8	45	*13.4*
New York			1								1	1	3	1				3	6	7	5	28	*8.4*
New Jersey												1	1			2	1	2	1	3	2	13	*3.9*
Pennsylvania	1		1				1	1				1	2	5	3	1	2	1	4			23	*6.9*
Delaware							1							1			1					3	*.9*
Maryland				1	1			1			1	2	1	1	1	4	3		4	1		21	*6.3*
Virginia						2		1	3	1			2	1	1	6	1		2		2	22	*6.6*
North Carolina									1		2		1			1	5		1			11	*3.3*
South Carolina							1	2	1						1			3		2		10	*3.0*
Georgia																				1		1	*.3*
Kentucky																				1		1	*.3*
Total	7	1	3	1	3	3	3	7	5	3	4	9	31	15	17	43	31	41	36	33	39	335	*100.2*
Per Cent.	*2.1*	*.3*	*.9*	*.3*	*.9*	*.9*	*.9*	*2.1*	*1.5*	*.9*	*1.2*	*2.7*	*9.3*	*4.5*	*5.1*	*12.8*	*9.3*	*12.2*	*10.7*	*9.8*	*11.6*	*100.0*	

(a) During this period Maine was, of course, a district of Massachusetts, and charters for her corporations were granted by the Massachusetts General Court.

TABLE III.

EIGHTEENTH CENTURY CHARTERS TO BUSINESS CORPORATIONS IN THE UNITED STATES, CLASSIFIED BY YEARS AND PURPOSES.

Purposes	Colonial	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791	1792	1793	1794	1795	1796	1797	1798	1799	1800	Total	Per Cent.
Banking		1	3		1		1	1			1	3	8	3		5	2			2	3	34	10.1
Insurance	1						1	1				1			4	5		3	6	5	6	33	9.9
Financial	*1*	*1*	*3*		*1*		*2*	*2*			*1*	*4*	*8*	*3*	*4*	*10*	*2*	*3*	*6*	*7*	*9*	*67*	*20.0*
Inland navigation				1	1	2	1	3	5	1	2	3	11	5	2	10	11	5	5	3	3	74	22.1
Toll bridge						1		2				1	10	6	7	14	6	14	7	3	2	73	21.8
Turnpike													1		3	6	6	10	11	15	20	72	21.5
Highway				*1*	*1*	*3*	*1*	*5*	*5*	*1*	*2*	*4*	*22*	*11*	*12*	*30*	*23*	*29*	*23*	*21*	*25*	*219*	*65.4*
Water supply	3												1			2	4	8	6	4	4	32	9.5
Dock	2															1			1			4	1.2
Local Public Service	*5*												*1*			*3*	*4*	*8*	*7*	*4*	*4*	*36*	*10.7*
Manufacturing										2	1	1			1		1	1			1	8	.3
Mining					1																	1	.6
Agriculture														1								1	2.4
Land																	1					1	.3
Commercial	1																			1		2	.3
Business (proper)	*1*				*1*					*2*	*1*	*1*		*1*	*1*		*2*	*1*		*1*	*1*	*13*	*3.9*
Total	7	1	3	1	3	3	3	7	5	3	4	9	31	15	17	43	31	41	36	33	39	335	100.0
	2.1	*.3*	*.9*	*.3*	*.9*	*.9*	*.9*	*2.1*	*1.5*	*.9*	*1.2*	*2.7*	*9.3*	*4.5*	*5.1*	*12.8*	*9.3*	*12.2*	*10.7*	*9.8*	*11.6*	*100.0*	

TABLE IV.

EIGHTEENTH CENTURY CHARTERS TO BUSINESS CORPORATIONS IN THE UNITED STATES, CLASSIFIED BY PURPOSES AND SOURCES OF CHARTERS

Sources of Charters	Financial		Highway			Local Public Service		Business (proper)		Total
	Banking	Insurance	Inland Navigation	Toll Bridge	Turnpike	Water Supply	Dock	Manufacturing	Miscellaneous	
United States	2									2
Maine	1	1	7	12		1	1			23
New Hampshire	1	1	5	19	4	1	1			32
Vermont			5	5	9	1				20
Massachusetts	7	5	5	14	9	15	1	4		60
Rhode Island	4	6	1	3	3	3				20
Connecticut	5	2	2	3	23	5	1	1	3	45
New York	4	3	3	1	13	2		2		28
New Jersey			4	5		2		1	1	13
Pennsylvania	3	4	5	5	5				1	23
Delaware	2		1							3
Maryland	3	6	4	4	3	1				21
Virginia	2	3	14		3					22
North Carolina			11							11
South Carolina		2	6	1		1				10
Georgia			1							1
Kentucky				1						1
Total Charters	34	33	74	73	72	32	4	8	5	335
Ancillary, additional, or Joint Charters	*5*		*8*	*4*						(a)*18*
Total Corporations	29	33	66	69	72	32	4	8	5	317

(a) One bridge and canal company occasions an additional subtraction.

TABLE V.

COMPARISON OF STATES WITH RESPECT TO POPULATION, 1800, AND NUMBER OF EIGHTEENTH CENTURY CHARTERS TO BUSINESS CORPORATIONS.

Sources of Charters	No. of Charters Granted	No. of Charters per 100,000 Population 1800	Percentage of Total Charters Granted	Percentage of Total Population 1800	Rank with Respect to No. of Charters Granted	Rank with Respect to Population 1800
United States	2		.6			
Maine	23	15.2	6.9	2.8	5–6	14
New Hampshire	32	17.4	9.5	3.5	3	11
Vermont	20	12.3	6.0	2.9	9–10	13
Massachusetts	60	14.2	17.9	7.9	1	5
Rhode Island	20	28.9	6.0	1.3	9–10	16
Connecticut	45	18.0	13.4	4.7	2	8
New England	*200*	*16.3*	*59.7*	*23.2*	*1*	*3*
New York	28	4.8	8.4	11.1	4	3
New Jersey	13	6.2	3.9	4.0	11	10
Pennsylvania	23	3.8	6.9	11.3	5–6	2
Delaware	3	4.6	.9	1.2	14	17
Middle States	*67*	*4.6*	*20.0*	*27.6*	*2*	*2*
Maryland	21	6.1	6.3	6.4	8	7
Virginia	22	2.4	6.6	16.6	7	1
North Carolina	11	2.3	3.3	9.0	12	4
South Carolina	10	2.9	3.0	6.5	13	6
Georgia	1	.6	.3	3.1	15–16	12
Other Southern States				.5		
Southern States	*65*	*2.9*	*19.4*	*42.0*	*3*	*1*
Kentucky	1	.4	.3	4.2	15–16	14
Other Western States				3.0		
Western States	*1*	*.3*	*.3*	*7.2*	*4*	*4*

THE APPLICATION OF STATISTICS TO ADVERTISING AND MARKETING.

By Hyman L. Roth, *Statistical Bureau, Metropolitan Life Insurance Company.*

When one mentions the term statistics, people are wont to associate with it the economist, the social worker, the government official, the college professor, or perhaps the insurance statistician, the financier, and the like. But the business man engaged in the manufacture and sale of some product, is rarely thought of in connection with the uses of statistics. And yet, statistical data and research methods have assumed vital importance and have been extensively used in various phases of business life. Business executives are not only searching for and utilizing the figures compiled by the national and state governments and other bodies, but are also themselves gathering and tabulating statistical data germane to their business. This is particularly true in the fields of advertising and marketing, to which this paper will be devoted.

The uses of various kinds of statistical data for the determination of markets, the application of statistical methods for checking up results, for apportioning sales quota, for measuring competition, for laying out advertising plans and selling campaigns—*specific instances* of how statistical methods and data have been used for these and other purposes will be presented below.

Attitude of Business Men toward Statistics. Nor does the business man refer to statistics in a slighting manner. On the contrary, he is attaching more and more significance to the possibilities and utility of statistics. Let me quote several items to bring out this point.

In an address before the teachers of advertising at the 1916 convention of the Associated Advertising Clubs of the World, S. Roland Hall, advertising manager of the Alpha Portland Cement Co., quoted a number of passages from letters that he had received from advertising and sales executives in answer to the query as to what they expected from students who

completed courses in advertising. Among the replies was the following:

They (those who have studied advertising) are inclined to emphasize the copy side and entirely overlook the statistical and research work that is an indispensable preliminary. I think that teachers might do well to teach students the usefulness of graphs and charts, train them to investigate, to ascertain populations in given groups, sales possibilities, etc. They should be shown how salesmen are routed by maps, and how selling effort generally is organized and directed.

The following passage, from an editorial in *Printers' Ink* of March 30, 1916, a weekly magazine for advertisers, is also indicative of the same attitude.

Uncle Sam is an indefatigable gatherer of statistics, and the publications of the Departments of Commerce and Agriculture are veritable mines of facts and figures which have been compiled at the public expense, and which are supposed to be for the public benefit. The usefulness of all this matter, however, is nothing like what it might be if it were properly brought to the attention of those who might make profitable use of it. Unless a business man himself takes the initiative, and writes to Washington for information, he is not likely to appreciate the broad scope of the work which is actually being done for him by the government.

Then, referring to a booklet issued and circulated by the Census Bureau, directing attention to publications of a statistical nature of possible use to business men, the editorial concludes:

We are glad to note that the need (that is, for publicity of statistical data) has at last been recognized by one government official at least, and we hope the practice will spread.

Another interesting indication of the attitude regarding statistics for business purposes, is the growing use of statistical terminology. Thus, in *Associated Advertising*, February, 1916, an article contains the phrase, "a movement which looks toward reducing the business death rate" etc. Again, in the March, 1916, issue of the same magazine, there is an editorial on the efforts of the Ingersoll Cost Accounting Committee of the Associated Advertising Clubs of the World, containing such phrases as the "high business death rate" and "when the

desired *figure facts* are obtainable, it will be possible to arrive at various *safe averages* for income and outgo," etc. In an interview reported in *Printers' Ink*, April 15, 1915, W. H. Ingersoll is quoted as saying: "The vital statistics of a business or department, like the vital statistics of a nation or government, may best be concentrated for preservation in the form of graphic charts." While passages of this kind can be said to be incidental, yet they are significant of the attitude of business men on this subject.

The general manager of a concern manufacturing talcum makes the following comment on the lack of statistics in that field as compared with other lines of business, *Printers' Ink*, Feb. 3, 1916:

> But in the talcum business, it has been altogether different. There have been no statistics, no appreciation of the real and possible demand, no accurate knowledge of per capita consumption. We are all of us, even the largest, losing far more by secrecy than we would gain by a free interchange of data and opinion.

At a meeting of the Advertising Club of New York, in March, 1916, John Lee Mahin proposed what is really the statistical method for measuring the "good will" produced by advertising. He said, as reported in *Printers' Ink*, April 6, 1916:

> First we can measure the amount of money spent over a period, say, of three years. We can take the amount of space and picture it by the graphic method. Then we can put against it the total amount of space it bought. We can cut that space up and say that a certain large percentage of it has been put into the propagation of the ideas. And that another smaller portion of the space, say, 5 per cent., has been devoted to making the street location of the house known; and 2½ per cent. to a name that fits the tongue easily or a mark to identify it; and 5 or 10 per cent. more to more or less inconsequential things.
>
> I say we could do that with more or less facility. We could do it also with competitive articles and check the good will of these against the good will of the goods in question.
>
> But that is not all. We could then send out into the field and canvass large enough groups of typical consumers and those who have influence on consumers and in this way get an *accurate approval of the state of mind* of those consumers and confidently believe that they are representative of the whole

mass of consumers. We should never lose sight of the fact that the opinions, desires, preferences of the consumers are *facts.*

Just one more reference of this kind, an editorial from *Printers' Ink*, June 29, 1916:

Indeed, the whole trend of the advertising business is straight away from the old methods of trial and error, and toward an even greater dependence on facts and figures. Nowhere is that fact more apparent than in the increasing use of statistics, which often indicate the advisability of a change in tactics before it becomes painfully evident in the sales total.

The foregoing passages are quoted to indicate, at the very beginning, the seriousness with which business men regard statistical data and methods as applied to their respective fields. Let us now pass to a consideration of a number of *actual instances* of the uses of statistics by the three following elements of the field of advertising—the advertiser, the advertising medium, the advertising agency. In citing the various instances, I have preferred to have those who have utilized statistical methods tell their own story in their own words, and have therefore quoted rather extensively.

USES OF STATISTICS BY ADVERTISERS.

The use of statistics by a manufacturer is well exemplified in the case of Robt. H. Ingersoll and Bro. in an interview reported in *Printers' Ink*, April 15, 1915:

In these days of aspiration for scientific management every executive is trying to get his business on a measurable, analyzable basis. The original unit of comparison for determining this almost always has to be the productiveness of the individual salesmen. Afterwards the measuring-stick is the territory. The Ingersolls are now coming to the third standard, units of population; a variation of the territorial idea, but yet a variation. The company now sells 46 or 47 watches per thousand of population; two or three per thousand in secluded sections, 100 or more per thousand in cities, but about 46 or 47 per thousand the country over. But how much *ought* it to sell?

To know the number of watches sold per thousand and the cost per thousand gives a much broader and sounder basis than the other way. We ask how many can be sold? The life of the average watch is so many years, and in that we

include breakage and loss. Replacement is so much, competition is so much. The relations of wealth and poverty, of factory and commercial and agricultural communities, are all figured in. Averages are found for state, sections and the country as a whole.

With these in hand we can turn around and make local investigations with entirely new and highly important resources of inquiry. Why are the sales per thousand greater in this place than in that? Why should it cost more to make fewer sales there? Territories show up in new light, in better focus, and we can see whether the need is primarily for one kind of help or for another, this kind of appeal or that.

So important do some people consider statistical research in its application to business problems, that they believe in the existence of a separate department for the sole purpose of conducting work of this kind. Thus, Chas. C. Parlin, Manager of Division of Commercial Research of the Curtis Publishing Co., in an article in *Printers' Ink*, October 22, 1914, entitled "Why and How a Manufacturer Should Make Trade Investigations," advocates the creation of research departments by manufacturers. A few paragraphs from this article will indicate the utility of statistical data for the purposes indicated:

Today the supply in most lines has caught up with the demand and a third very important function devolves upon the manufacturer; namely, to develop his markets. This function involves first of all a thorough knowledge of his existing markets and of all those influences which are operating to affect them. It seemed natural enough in the earlier stages of industrial development for the manufacturer to confine his attention to the making of goods and to entrust to an outside sales organization the second function of getting the goods to the consumer. It is still advantageous in many lines for the manufacturer to reach the retailer through jobbing connections, but no manufacturer, however efficient and honorable the middlemen handling his product are, can afford to be without firsthand knowledge of his markets. Every manufacturer should know where his goods are sold, who buys them, and why they are bought, what type of men are selling his goods to consumers, what influences are affecting them, what their sales methods and sales costs are, to what extent they are real factors in making sales and to what extent they are only order-takers.

Every manufacturer should know whether he has a uniform distribution or whether there are certain sections and communities within sections where sales are subnormal; many manufacturers reaching the retail trade through middlemen seem to have very little of this information.

Mr. Parlin states further:

A certain manufacturer in the central west was interested primarily in breaking into the New York markets; research showed him that totally neglected at his own door there lay a larger market easier to get and likely to prove more profitable than the coveted New York market; research showed another manufacturer that his distribution was far from uniform, another that he was restricting his line to jobbers when the possible sale for his goods was almost confined to those stores which aimed to buy direct; another who sold only direct that a major portion of the opportunities in his field could be best reached through jobbing channels.

As regards the scope of commercial research, Mr. Parlin states:

Research work should not only be dominated by honesty of purpose, but it should be conducted from the student standpoint of truth for truth's sake. Lines of inquiry that appear likely to prove of practical value should, of course, be pursued. But that which appears academic should not be neglected, for it frequently happens that what appears to be academic turns out to be highly practical, while something which appears likely to be practical turns out to have little value. . . . Commercial research work involves three distinct phases: First, library work; second, field work; third, formulating conclusions.

The first step naturally is the study of printed sources, such as the census reports and other government publications. The research department may often throw light upon a business by merely graphing census figures. Often we have found a manufacturer with the latest census reports at his elbow, but deeply interested in maps and graphs of the same census material as it applied to his own business, indicating, that while he had perhaps read the figures, they came to him in a new light as he saw them graphed.

In advertising and selling, as in vital and social statistics the importance of reducing figures to a rate per hundred or thousand basis has been recognized. Says C. C. Casey in an article, "Graphic Sales Pictures That Analyze the Business," *Printers' Ink*, January 20, 1916:

Many of the big sales organizations use the "quota" system in compiling certain of their sales and advertising statistics, and these figures remove some of the inequalities of territorial or agency sales.

The quota in Arizona, may, for instance, be ten sales a month and in New York ten times as many, but the tabulation would show, not the *sales*, but the *per cent. of sales to quota*—75 per cent. of quota in each state would indicate equal comparative results, even though it did only mean that Arizona made 7½ sales and New York 75 sales.

The most graphic method, however, of showing sales or advertising by territories, or by states, or by salesmen is the "per prospect," "per hundred prospect," or "per thousand prospect" method. . . .

If you say that the Arizona sales organization—whether it be salesmen, jobbers or dealers—sold 333 units of your product per thousand prospects in a year and New York sold 111 units, the comparison has a "Jim Jeffries punch" which is likely to jar somebody into demanding a reason.

Another instance of the use of statistics and the rate method was recited by N. C. Kingsbury, Vice-President of the American Telephone and Telegraph Co., at the 1916 convention of the Associated Advertising Clubs of the World, reported in *Printers' Ink*, June 29, 1916. Mr. Kingsbury said:

Our national advertising campaign began in June, 1908. . . . For the five years of 1904 to 1908, inclusive, we gained 1,690,078 subscribers, and this gain was 1.72 telephones for each hundred of the total population of the United States. That was before our advertising campaign began.

Now let us take the period from 1908 to 1913, inclusive, omitting, as you will note, the years 1914 and 1915 in order to avoid the effect of abnormal conditions due to the European war. During these five years, while our advertising campaign was in progress, we gained 2,199,964 stations, and that gain was 1.95 telephones per 100 of the total population of the country, so that during the period covered by our national advertising the gain in telephones was .23 of 1 per cent. greater than during the period when we were not advertising. If you will apply this .23 of 1 per cent. to the total population of this country you will notice it represents a large number of telephones. And this gain was made in spite of the fact that the possibilities for new business were considerably less in the latter period than in the former period.

Another very interesting instance of the use of statistics

was described in an article entitled "Testing the Value of Inquiries," also by C. C. Casey, in *Printers' Ink*, January 27, 1916. The advertising of a firm manufacturing machinery was adversely criticized by the management on the score of poor sales results in following up the inquiries with salesmen. So critical did the matter become that the discontinuance of further advertising was being considered. Whereupon the advertising manager made a thorough statistical analysis of the records of inquiries and sales, and presented his results in both tabular and graphic form.

The *length of the sales lines*, showing sales per thousand possible customers, *followed the length of the advertising lines*, showing inquiries per thousand possible customers.

When inquiry lines were long, showing a large number of inquiries per thousand possible customers, sales lines also were long, and *vice versa*—in a manner that was graphic.

There were many variable elements, of course—greater efficiency of men, better crop conditions, and a lot of other things—but the *tendency* was for sales to "grow thick" exactly in proportion as advertising inquiries were "planted thick."

In other words, even though salesmen ignored inquiries, their prospect list as a whole was educating itself to buy, and was buying freely or rottenly in proportion to the number who could be induced to write the company for more information.

Another instance of the use of statistical analysis for determining the value and nature of inquiries, was presented in a talk before the Adcraft Club of Detroit by Edwin A. Walton, Advertising Manager of the Burroughs Adding Machine Co., reported in *Printers' Ink*, Nov. 4, 1915:

Our analysis of our business experience, covering hundreds of different letters, folders, magazine advertisements on every phase of our business, proves definitely and conclusively four things:

First: The more educational our message, the fewer the inquiries.

Second: The more Burroughs machine we talked, the fewer the inquiries.

Third: The more mere curiosity we excited, the greater the number of inquiries, and

Fourth: The more valuable looking the free booklet we offer, the greater the number of inquiries.

Statistics as a Guide for Copy. The realization of the above facts gave the Burroughs Adding Machine Co. also a splendid guide as to the kind of copy that was best suited for their purposes. Again, to quote Mr. Walton:

> Now we are reasoning this way in our advertising, that if the prospects in the country, numbering two million or more, really knew what a Burroughs would do for them in the way of saving time, insuring accuracy, and giving them without any cost the facts and figures of their business, on which to build better profits—if they really *knew* this, they would be clamoring to buy. They would mob our hundred and seventy offices around the country. They would be sitting on the doorsteps in the morning waiting to buy machines. Now that's the truth. If they only *knew*. We believe that. It is, then, an educational problem.

A further excellent instance of the use of the statistical method for obtaining a guide for copy, was the recent prize contest on the uses of Bon Ami. Says R. S. Childs, general manager of the Bon Ami Co., in an article in *Printers' Ink*, August 10, 1916:

> The prize contest had considerable value, however, in fulfilling its *primary purpose of business research*. The traditional theory of the uses of Bon Ami, on which our advertising copy rests, is based on very illusive data. . . .
>
> By tabulating the replies we produced a big chart, showing the seventy leading uses for Bon Ami and to some extent this chart guides our advertising. It leads us, for example, in an advertisement showing the cleaning of a bathtub to put a can of Bon Ami powder, rather than a cake, into the hands of the model, whereas in a window- or mirror-cleaning advertisement we take pains to show a cake, there being a clear preference on the part of housewives along these lines in the prize-contest returns.

For Figuring Advertising Appropriations. The statistical method is used extensively in determining advertising expenditures and appropriations, especially with regard to the localities and mediums in which to advertise. For example, Lee Anderson, in an article, "Some Suggestions on Handling the Advertising Appropriation," *Printers' Ink*, June 22, 1916, recites an instance of the study of a certain advertising problem in which he found that, "with 65 per cent. of his distribu-

tion in towns of 5,000 and under, the advertiser was spending 85 per cent. of his appropriation in publications whose circulation was in cities of 25,000 and up."

The following is another instance of the use of the statistical method in the consideration of the advertising appropriation of a national advertiser. To determine how much should be appropriated by this firm for advertising in its various territories, it was proposed to make a test over a period of two or three years by running advertisements in certain territories operated by this firm, and by not advertising in other territories, and then checking up the results. The article describing this analysis, "The 'Saturation Point' in Advertising Expenditure," by C. C. Casey, in *Printers' Ink*, September 9, 1915, is here quoted as a particularly good illustration of the intensive use of statistical methods:

> In an analysis, however, to find the right territories, it was discovered that some territories already had been receiving more advertising than others, both in the magazines, because of varying circulation, and in the varying attitude of mind of the different branch managers toward advertising.
>
> When this discovery was made, the territories were sorted into six groups, according to the amount of advertising done in each. The amount of advertising was at first taken as the number of prospective customers reached (and the number of times reached) both by mail and through the magazines.
>
> This, however, was not found satisfactory because of the varying kinds of advertising used and because of variation in circulation of the magazines. . . . . A better method was found in taking the *inquiries* received from the advertising for each territory, ignoring those received direct by the branch managers, that is, those not coming through the home office. . . . .
>
> Because of the varying number of inquiries and the varying number of prospective customers in the different territories, it was decided to reduce the inquiries per territory to the "inquiries per thousand prospective customers" in each territory. This was done by dividing the total number of inquiries in each territory by the number of thousand prospective customers in each territory. . . . .
>
> The territories were then regrouped into six groups, according to the amount of advertising done. In group 1 were put all agencies with less than 100 inquiries per thousand prospective customers; in group 2, all who had between 100 and 150;

group 3, all between 150 and 200, and so on until group 6, which had all territories that had more than 300 inquiries per thousand prospective customers.

Then the total sales were taken for all the agencies in each group, and these being divided also by the number of thousand prospective customers in the group of territories, gave the *sales* per thousand prospective customers in each group.

Then the amount of these sales was obtained by multiplying by the average sale price and the total in dollars was used as a basis to estimate percentage of the advertising cost.

Enough of this article has already been quoted to show the intensive use of statistical methods in the case in question. The following paragraph from a series of articles in *Printers' Ink*, in 1915, is also indicative of the application of statistics in determining the advertising appropriation:

It is a fact, however, that the ratio between advertising expenditures and gross sales, when it can be obtained in the form of an average for the entire industry or the major part of an industry, may be very useful. The concern which is able to approach the subject of an advertising appropriation with the knowledge that the normal or average advertising expenditure in its field is 7 per cent. of its gross sales will find its problems materially simplified. Its analysis of the market with respect to its own product will indicate wherein that normal average must be exceeded, and wherein it may reasonably be expected to prove adequate.

George F. Lord, Manager Advertising Division, Du Pont Powder Co., in discussing the problem of advertising appropriations in *Printers' Ink*, March 4, 1915, states:

I am convinced that more failures in advertising are due to lack of analysis of conditions than to any other reason. For lack of such analyses many concerns that sadly need advertising fail to use it, some advertise who should not, and many advertise "too much, too quickly," creating sales demand they cannot meet.

An analysis of a business along the lines here suggested will often develop unthought-of possibilities of expansion or obstacles to success that must be surmounted or circumvented before an advertising campaign can succeed.

He then presents a very comprehensive list of items, the filling in of which would involve the utilization of statistical

data already compiled, or the conducting of new investigations to obtain the necessary information.

Studying Competitive Advertising. A most novel and interesting example of statistical analysis is contained in a study of the competitive periodical advertising and literature of several firms in the same field, described in an article in *Printers' Ink*, October 14, 1915, entitled "Sizing Up the Other Fellow," by S. W.:

> To get down to practical issues, the analysis divided itself into three parts. One took up the advertising, national and trade, of all the companies in the field; the second regarded the sales-promotion booklets sent out from various offices in response to inquiries of dealers and customers and distributed through dealers, jobbers and salesmen. This included sales promotion methods. The third part concerned the talking points used by various other companies in putting forth the advantages of their respective chests.
>
> The work of finding out about the national advertising of competitors was simple. This part of the analysis came, almost completely covered in detail, from the offices of various magazines willing to give the data. It resolved itself into securing the space requirements of each company as the information was given by the leading national magazines.

The data thus furnished was worked up in chart form, of which the author of the article states:

> The value of such a chart, since practical value is the real object, could best be brought about and "cashed in on" after a second year. Comparative statements are always more valuable than simple figures. By comparing what a company has done one year with what it did the preceding year, a person can get a fair idea whether the company is increasing or decreasing appropriations and thereby judge, in a crude but somewhat definite way, whether the company has gone ahead or behind.

Charts were also worked up for the second part of the investigation, which dealt with booklets, correspondence, and other sales-promotion methods of competitive companies:

> The use of such a chart is simple: it shows at a glance, how much follow-up work other companies are doing, how much material they send out and the interval of time between letters. Then, it can be judged with some accuracy which of the companies are enjoying success in proportion to the efforts put forth. . . . .

Two such charts, one for each of two successive years, would enable a company to judge which of its competitors had particularly increased its efforts in such direction and so a company would be able to tell something of the progress in organization and promotion work made by competitors. So it would happen, as years passed, that these charts would increase in value, each one of them showing up some change in the methods of various companies: then as one or two of the companies might advance far ahead of the others, or drop back, the reasons could be conjectured with a degree of exactness. This, indeed, is a laboratory method of investigation.

As to the third part of the investigation, dealing with the talking points used by the various companies, the following passages will be of interest:

After taking each company separately and listing its talking points and the number of times each point has been used in folders, booklets, national advertising, and miscellaneous respectively, then it was advisable to have a summary made of all the talking points regardless of the companies using them. . . . .

The final part of the analysis made under section three was to give in simple, terse manner the exact methods of approach of various companies. . . . . Methods of attack and appeal were thought out with newer vision after that investigation was completed.

As for the results and value of this investigation, the following conclusion speaks for itself:

It was practical in that it put into usable form what all the competitors in the field were and are doing in way of sales-extension work, sales-promotion work, and efforts to get new and repeat business. The investigation developed in itself a good bundle of notes and ideas and plenty of new suggestions as to methods for reaching and coöperating with dealers, and some eye-opening facts regarding merchandising methods and principles.

Analyzing and Locating Markets. Statistical data and investigations have also proved of much value for purposes of analyzing and cultivating present markets, and for discovering and locating new markets for merchandise. The instances already cited of how the Ingersoll firm uses statistics and the suggestions of Mr. Parlin are good examples. Several other cases of interest may also be given in this connection.

An interview with F. D. Gould, Retail Sales Director of the Regal Shoe Co., reported in *Printers' Ink*, April 26, 1916, refers to a certain change of plan in the general sales policy of that company. The following paragraph from that article is significant of the use of statistics in dividing the country into districts or zones.

Immediately it became apparent that any plan of this kind could not be operated from the Boston office. So, after an analysis of conditions, the country was divided into fifteen zones, following the distribution of the per capita wealth of the country, population, and so far as possible, the lines of present Regal district boundaries.

The following quotation from an article in the June, 1916, issue of *Associated Advertising*, entitled "Selling Lessons from the Shop," by Edward S. Babcox, Advertising Manager of the Firestone Tire and Rubber Co., is also illustrative of the use of statistical data for market analysis:

In a certain city the other day, I talked with a man who was erecting a wonderful garage. When I first saw him he was planning to take care of several thousand motor trucks. He was surprised when I showed him after a little analysis and investigation, that there were only 600 or 700 trucks in his whole territory, and that he could not hope to get business from more than 10 to 20 per cent. of these. These facts caused him to alter his plans.

In a big national marketing problem, the sales manager must analyze his field just as carefully. The United States Census figures provide unlimited information and enable him to assign sales quotas to each territory in an intelligent and accurate way.

He knows, for example, that there are about 5,500,000 families in the United States having an income of $1,200 and about 3,250,000 families with an income of $1,800 or more. If we consider $1,800 the minimum income for an automobile-owning family, statistics prove that the field is 59 per cent. developed. If you work on the $1,200 basis, the field is 35 per cent. developed.

The live sales manager knows there are today about 1,750,000 automobiles in the United States. He knows there are 10,000 in St. Louis, for example. He knows there are 23,295 people in St. Louis who can afford an automobile, and he knows that about 43 per cent. of these possible automobile buyers now own one or more cars. With these figures to guide him, he can direct successful selling efforts in St. Louis.

The American Radiator Co. is another concern that has utilized statistical data to excellent advantage in planning local advertising campaigns in certain territories. Louis Bruch, Vice-President of the Company, gives an interesting statement in this connection, in *Printers' Ink*, April 8, 1915:

Before we will consider putting on a campaign in a certain city there are many facts we must know. We want to know how prosperous the community is. For example, we are now considering adding papers in cities dependent on potteries. Potteries are very busy these days—busier than ever before—on account of the favorable tariff and war conditions. We want to know what the bank clearings are; if the locality has any advantages in the way of better soil or crops, mining property or other things which make for continued prosperity. We want information as to the make-up of the people so that we may know if they are of a type that will respond to our advertising; what kind of farming is done in the surrounding country; all the figures and facts available about the earning power of the residents; what kind of homes they have, and other data of a kind which will help us to determine in advance whether or not it would pay us to put on a campaign.

Proctor & Gamble also base their sales policies on actual market facts, ascertained by a study of conditions as they are in the field. In an article by S. C. Lambert, in *Printers' Ink*, April 27, 1916, appears the following passage:

There is the widest possible variation in the methods of marketing Ivory Soap and Star Soap, for example, and Crisco requires a still different combination of methods. Each campaign is based upon a study of conditions as they actually are, not as they were forty years or so ago when Ivory Soap was a new brand. This constant and intensive study of actual conditions, with the resulting adaptation of the selling campaign to fit the conditions, are the features of the company's work which have greatest interest for manufacturers in other lines.

A final instance that I shall cite of how the statistical method was used in analyzing a market is the case of Novo Engines, described in an article, "Saving a Business by Switching to New Market and Plans," *Printers' Ink*, May 27, 1916. In this case an analysis brought out the advisability of entering the city market, whereas theretofore only the rural territory was cultivated.

It was found when the investigation had been completed that there was a variety of uses to which the new gasoline-engine might be put in the city. There was hoisting in the building and contracting trade. The big hoisting jobs on new buildings were done by big steam-engines or electric current. But there were hundreds and thousands of small hoisting jobs, too small to call for a large steam-engine, too small to warrant the whole time of an engineer and assistant, and too expensive when done by hand labor. . . . .

Then there was the pumping to be done by builders, contractors, and engineers, such as getting the water out of a cellar or a ditch. One contractor paid four men two dollars a day each for several days to empty a ditch of water, and the Novo Engine with pump could empty in less than a day at a cost of thirty cents.

An Intensive Study of Retailers. R. P. Spencer, of the American Optical Co., gives the following account, in an article entitled "A System to Stop Guessing in Dealer-relations," *Printers' Ink*, May 18, 1916, of an exhaustive study that he made along the lines indicated by the title:

Some years ago, when I was merchandising tinware and enameled ware, it occurred to me that our salesmen knew a great deal about our retailers and our prospects that would be very helpful if we had it on file in the office. Such information could be used in many ways—in writing the individual retailer, in getting up circular letters, as guidance in establishing policies and in the successful handling of 101 details. On considering the subject further we saw that, while the salesman already possessed much knowledge about the retailer and his town, he could easily gather a great many other useful facts for us by asking a few questions and by doing a little observing. Charting these data on cards would give us a comprehensive bird's-eye view of the dealer, his store, his clerks and everything else that vitally concerned him. To get the required information we prepared a blank containing sixty-three questions. Our salesmen were requested to fill out one of these blanks for each merchant on whom they called. Of course all these questions were not asked in one trip, but answers were gradually compiled in several visits.

Then follows a list of the sixty-three questions which constituted *in toto* a most searching analysis of the conditions and merchandising methods of the retail trade. As regards the value of this analysis, the following passage is of interest:

Supposing we were planning a trade-paper campaign. By getting the answers from our cards to questions numbers 1, 2, 3, 4, and 5 we could know what publications to use and have a fair idea of the kind of copy to insert. If we were looking for new talking-points, the answers to question 10 would give us a mine of material. Answers to those questions about what our competitors were doing furnished us with a lot of valuable tips, both for the improvement of our products and of the methods used in marketing them. How could we prepare consumer advertising intelligently without referring to those cards again and again? In a word, how could we do anything, and be sure that we were right without consulting the facts recorded in our files? After we started this system and began to realize how valuable the information was, we saw that we had always been working in the dark before and had been guessing at things we should have known.

A similar instance of obtaining data regarding retailers is that of the Westinghouse Co., described by R. E. Dildine in *Printers' Ink*, May 25, 1916:

The advertising department has on file a salesman's report on every distributor, which contains detailed information that is very valuable as a basis for planning and distributing dealer-help material.

These data include, for example, such details as the number and size of the dealers' windows, size and location of the store, the class of customers, the number of clerks employed, the mediums of local advertising employed and the kind of dealer-helps that are used and the way they are used.

These reports are a check on waste of advertising materials, as the company furnishes all of the usual selling-helps, such as street-car cards, posters, booklets and newspaper cuts.

Miscellaneous Uses by Advertisers. James Melvin Lee, Director of the Department of Journalism of New York University, sent a letter to a number of firms, and asked among others, the two following questions:

If you had at your disposal an investigator who was well qualified to dig for helpful facts, at what leading tasks would you set him?

What class of information has proved to you to be the most helpful in the past in enabling you to get results from your advertising?

The replies that he received, presented in an address before the American Association of Teachers of Journalism and re-

ported in *Printers' Ink*, April 27, 1916, are full of suggestions regarding the actual and possible uses of statistical data and research work.

J. M. Campbell of the Proctor & Gamble Company is quoted as saying:

Not one business house in a thousand knows the facts about its product—knows what there is about it that appeals to the public.

I happened to know of a very large manufacturer of a product which is used in a very considerable percentage of the homes of the United States. He has spent millions of dollars in advertising the fact that this product has such and such a quality. A house-to-house investigation covering 600 homes and an investigation through the mail covering over 1,000 women brought to light the fact that only one person had been influenced by the repetition for the last twenty years of that special feature of this advertiser's advertising. On the other hand, 80 per cent. of the women who answered our inquiry expressed themselves as wanting this particular advertiser to do such and such a thing, something which he was not doing and did not know his public wanted him to do.

R. P. Spencer, Sales Manager of the American Optical Co., stated that he was actually going to give to an investigator the following assignment:

I intend to make arrangements with a trained investigator to secure important facts which will enable us to plan a comprehensive sales-advertising campaign. In the first place, he will arrange with schools, factories, stores—in short, business institutions where work varies—to find out first, how many people are actually wearing glasses at the present time. Second, how many people should have glasses. Third, whether applicants for positions in these places have to pass any eyesight test or answer any questions in regard to it. Fourth, whether an oculist is regularly employed to test the sight of the employees in the same way as most concerns have a doctor to look after the physical welfare of their employees. Fifth, to find out from wearers of glasses whether they have been influenced by advertising to ask by name for any particular kind of frame, mounting or lens. Sixth, to find out the percentage of people who have their eyes examined by an oculist and then take the prescription to an optician, and the percentage of people who have their eyes examined by an optometrist, who both examines the eyes and furnishes glasses. Seventh, to ascertain the percentage of people who are imprudent

enough to take a chance on their eyesight by buying glasses from the five-and-ten cent stores, fakirs, etc., without having their eyes examined by some one competent to do the work scientifically. To find out from the oculists, optometrists and opticians what trade-papers and scientific magazines they read, so as to make a tabulation by percentages of those which are most popular and the leading features of these magazines. Eighth, to secure information as to how much advertising is done by the oculists, optometrists and opticians, and the division of expenditure according to the kinds used and the usefulness of each kind. Ninth, to find out the source of supply of the oculists, optometrists and opticians, so that we may secure percentages as to which jobbers are the most popular and the reasons for their popularity. Tenth, investigation to be made with the optical jobbers to find out territories covered, selling methods pursued, advertising, etc.

USES OF STATISTICS BY ADVERTISING MEDIA.

All the instances thus far cited referred to uses of statistical data and methods by advertisers. They constitute one great unit in the advertising world. A second unit in the field of advertising is embraced in the term "media," that is, magazines, newspapers, trade journals, posters, etc. Advertising media utilize statistics most extensively for both administrative and research purposes. Let us consider some specific examples.

Circulation Statements. It is obvious that before an advertiser will sign a contract to use advertising space in a newspaper or magazine, that he will require a statement regarding the quantity and quality of the circulation. This is particularly important in view of the advertising rates now prevailing —a double page spread in a certain weekly costs $12,000 for one issue. Obviously, the advertiser wishes to study this information as to circulation, and to make comparisons of one magazine or newspaper with another. This was a difficult task as long as each magazine and newspaper would make up its own statement in the way it saw fit. For example, some newspapers would include in their circulation all the copies printed, while the advertiser is interested only in the number of copies sold. Then again, the advertiser wants to know how much of the circulation of a newspaper is in the city, and how

much is distributed in nearby suburbs. Other data of this kind were necessary for valid comparisons.

Of much interest in this connection was, therefore, the organization of the Audit Bureau of Circulations which it is worth our while to describe in some detail, because its reports are tabular, statistical statements, pure and simple.

The Audit Bureau of Circulations issues uniform, standard, and audited circulation statements of those publications that are members to advertisers and advertising agencies that are members of the Bureau. Inasmuch as different data are required for different classes of publications, five forms are used, one for each of the following classes: daily and Sunday newspapers; weekly, semi-weekly, and tri-weekly newspapers; magazines; farm papers; and trade, technical, and class journals.

Each of these forms contains very comprehensive statistical data regarding the publication concerned. The magazine form, for example, gives both the average paid and unpaid circulation, and separates the paid into mail subscribers and sales through newsdealers. Lest a certain issue be quoted by the publisher, that because of a special feature had an inflated circulation, the publisher must show the variation in the circulation of the last five issues. Then there is a tabular presentation of the distribution of the circulation by individual states and by geographic groups, both as to mail subscribers and sales through newsdealers. In addition, there is a statement of the circulation in cities of 100,000 and over, in cities of from 50,000 to 100,000 population, from 25,000 to 50,000, from 10,000 to 25,000, from 2,500 to 10,000, and under 2,500. This enables the advertiser to know what percentage of the circulation is in large cities and what percentage reaches the rural communities, a most important item.

The publisher is also required to specify the particular class, industry, or field covered by his magazine, also to give such information as the percentage of renewed subscriptions, data as to subscribers in arrears, whether premiums are offered to subscribers, etc. In short, there is a complete analysis of the quantity and quality of the circulation. The trade journal form goes even further in stating how many subscribers are

owners, managers, wholesalers or retailers, and in giving similar pertinent information.

Analysis of Advertising and Reading Matter. Statistical methods have been used very extensively for purposes of analyzing advertising and reading matter. Thus, the May, 1916, issue of *Advertising and Selling* contains an article on "A Graphic Study of Six Years Magazine Advertising." This article describes a study based on the number of lines of advertising carried by 60 representative magazines from January, 1910, to March, 1916.

The Butterick Publishing Co.—publishers of the *Delineator, The Designer,* and *The Woman's Magazine*—ran two advertisements in *Printers' Ink,* January, 1916. One gave an analysis of the reading matter that appeared in these publications during 1915. All the reading matter was divided into ten classes, for example, the home, kitchen and table, fashion, etc. The number of agate lines devoted to each was stated, and the matter was presented graphically in circular form, segments representing the percentages of lines devoted to each topic. The second advertisement presented a similar analysis of the advertising carried by that company in 1915. Going even further, the Curtis Publishing Co. has a checking department, "which regularly examines all the leading publications and measures and records the amount of space used by each advertiser. From these figures are prepared totals by weeks, months and years, by individual advertisers and groups, by large-space users and small-space users, by types of publications, and by other classifications."

The *Chicago Tribune* published a comprehensive analysis of Chicago newspaper advertising, containing in both tabular and graphic form complete advertising records of all Chicago newspapers for 1915. Display and classified advertising are treated separately. Each important industry or line of business is given in considerable detail. For example, the section on Automobiles and Accessories gives the number of agate lines of this class of advertising carried in 1915 by each of seven newspapers, and gain or loss over the previous year. Then the figures for each newspaper are given separately as to gas cars, electric cars and accessories. There is also given an

interesting table, based on a poll taken by the Firestone Tire and Rubber Co., of the rate per line per auto owner for each newspaper. Other classifications, such as Department Stores, Groceries and Food Products, are similarly treated.

At the 1916 convention of the Associated Advertising Clubs of the World, Paul E. Faust, touching upon this general topic in an address on "How Newspapers Can Organize Their Market," said:

> If a quarter of the income goes to wearing apparel products, it is evident that this is of great interest to the home. If 50 per cent. of the average income goes for foods, then food products can be seen to be a very live issue. If 10 per cent. of the income goes for furniture and house furnishings, it is reasonable to believe that these items are entitled to editorial attention so that the reader may be guided, counseled and given very much desired latest information on the subject.

He then quoted the figures of the *Chicago Tribune* on the amount of text devoted to various departments.

Realizing the importance of furnishing present and prospective advertisers with accurate data along definite lines of interest, The Curtis Publishing Co. instituted a Commercial Research Division, which has made a number of investigations of extreme interest. As to the functions of this Division, let me quote from *Obiter Dicta*, a Curtis house-organ:

> Broadly speaking, the duty of this division is to ascertain, by personal investigation, the conditions, manufacturing and selling, that exist in various trades and industries, and to interpret these signs into statistical expressions of tendencies and future possibilities.
>
> With this material in hand the Company's representatives may come to a manufacturer with something to give him that will be worth his serious attention—information as to the condition and extent of his national markets, facts that may suggest new merchandising methods, and tables and charts showing in graphic detail many points that before may have been matters for conjecture alone.

An instance of the work of the Curtis Research Division is an investigation of the textile field. In making this investigation, Mr. Parlin, the head of the division, visited 165 cities, conducting over 1,000 interviews, traveling over 32,000 miles. A year was spent in studying the textile industry, and the final

report consisted of four volumes—about 2,500 pages including over 100 charts and 12 maps.

Another interesting volume prepared by the Commercial Research Division is "An Encyclopedia of Cities" containing an estimate of the "trading" population and of the department store business in every city of the United States of over 5,000 population.

The encyclopedia is divided into states, with the cities in that state alphabetically arranged, and after each city is given the following information:

(1) The census population
(2) The native white population
(3) The trading population (that is the census population plus the number of people living outside the city who *regularly* trade in the city, and minus the number of people living in the city who *regularly* trade outside the city
(4) The predominating nationality
(5) The leading dry goods stores and their total estimated volume of business.

A most stupendous investigation of the automobile industry was also made by this Division. A four volume, 3,000 page report was the result. Among other reports of this Division are those on Food Products and Household Supplies, and Advertising Possibilities of Pacific Coast Industries. It is of interest to note that besides this Division for purposes of pure research the advertising department of the Curtis Publishing Co. also maintains a Statistical Division.

A case of similar research work conducted by a local newspaper is that of the *Chicago Tribune*. This newspaper, realizing that an out of town firm advertising or planning to advertise in the city of Chicago, would find it helpful to have definite data of local conditions, made a most thorough investigation of the city from various standpoints of business interest. This investigation is summarized in a book entitled "Winning a Great Market on Facts," published in 1916. A few paragraphs from this book will indicate the detailed use of statistical methods:

It took work—and lots of it—time and money for the *Chicago Tribune's* Merchandising Service Department to break up the population of Chicago into so many separate units, to

study, analyze and classify these districts, to be able to say with positive assurance "We know" and be conscious that the information was not based on theory or casual investigation, but on block by block canvasses. . . . .

It is for these reasons, then, that the *Tribune's* trained investigators, statisticians and merchandising experts divided this great city by the lake into 48 separate districts.

The *Chicago Tribune* through this Merchandising Service Department can give you the whole story of each of these districts, tell you the average rents, the buying habits of the tenants and how many Germans, Italians, Poles, etc., are in each district. In fact, put its finger on the hundred and one items of knowledge that determine why people buy and why they don't. . . . .

By this we do not mean to imply that the *Chicago Tribune* has made a personal investigation of the buying and reading habits of each and every housewife in Chicago. But we have expended a fund of time and money in investigating a sufficient number of housewives in each unit of Chicago's population, so that the *Tribune* can furnish you facts and figures, based upon the law of averages, which have been proved correct time and time again.

The *Tribune* has analyzed the Chicago market even more exhaustively than it has Chicago's population. The number of dealers in each line and their locations by district (that is, exact information as to the character of their trade), as well as the attitude of the dealer, small and large, and department stores toward advertised products, new lines, established lines, window and inside display, demonstration, and other means of pushing sales—all this is part and parcel of the *Tribune's* fund of data.

Newspapers and general magazines are not the only media that advantageously utilize the services of statistical data and research. The same tendency can also be noted in other classes of advertising media. Thus, a poster advertising concern—the Ivan B. Nordhem Co.—in an advertisement in *Printers' Ink*, May 4, 1916, refers to its statistical department that furnishes valuable information for guidance in the selection of territory. A book issued by the New York Car Advertising Co. contains considerable data on the various boroughs of New York City and on the individual car lines. Trade journals also gather and publish data on the industries that they cover. Moreover, advertisers and advertising agencies are expecting trade journals to be of service along these lines.

Publishers of farm journals form another group that are enlisting the services of statistics. Thus, the "Standard Farm Paper Year Book for 1916," issued by the Research and Service Department of the company publishing the *Standard Farm Papers*, contains the following introductory statement:

In compiling the Standard Farm Paper Year Book for 1916, we have endeavored to give the buyer of advertising space a comprehensive collection of agricultural information in condensed form.

We are headquarters for reliable, detailed information covering the production, resources and purchasing power of the American farmer. Should you desire specific information on any special phase of the subject we will be glad to furnish data covering your individual requirements without obligation.

The book then quotes, extensively, from statistics compiled by the Census Bureau, the United States Department of Agriculture, and other sources.

Just one more instance of the use of statistics by farm journals. In February, 1914, the publisher of *Successful Farming* made formal announcement of the establishment of a Consultation Department. The following paragraph appeared in the announcement, showing that the new department was really to be a statistical or research bureau:

For many years we had hoped that some day we could increase the line of detailed and comprehensive information covering the resources, production and purchasing power of our field which we are furnishing our patrons, and give more data on the possibilities of merchandise development through the different channels that reach the farm home.

A most interesting accomplishment of this department is the set of so called Definite Data Maps. In the words of the publisher, these maps "comprise a thorough analysis of the buying power of the American farmer and the best methods of distributing goods to him. Compiled by counties they give information for any part of any state of the Union. And geographically, portray at a glance the general centers of production." At the time of this writing, sixty Definite Data Maps were ready for distribution, including the following general heads: Soil Elements, Farming Area, General Valuations, Crop Yields, Farm Livestock, Operation Expenses,

Farm Tenure, Merchandise Distribution, and Farm Paper Circulation.

As an illustration of the practical value of these maps, a circular published by *Successful Farming* gives the following suggestion for their use to the mail-order advertiser:

> They will show him how he can most economically reach the different areas from which he can expect the most sales, where are found the best crop conditions, where the most money on deposit, where fewest retail dealers; as well as other essential things.

USES OF STATISTICS BY ADVERTISING AGENCIES.

The advertising agency constitutes a third unit in the field of advertising. The modern advertising agency is equipped to render the advertiser a very comprehensive and diversified service. It will plan and lay out the advertising campaign, conduct preliminary market and trade investigations, devise trade marks and packages, write the copy, attend to the art and printing, write booklets, select media, check results,—in short, an advertising agency is in a position to execute virtually every detail involved in the advertising and marketing of a product. Advertising agencies also utilize the services of statistics. In the first place, any of the instances of the uses of statistics by advertisers, described above, may be worked out by the agency in its service to the client. Then again, the "space buyers" of agencies make ample use of circulation figures in selecting the media for an advertising campaign. In addition, some agencies have established statistical or research departments for purposes of making market and trade investigations or other analyses that may arise in the course of their work. The following quotations present actual instances of the uses of statistical data and methods by advertising agencies.

In answer to a letter asking the editor of *Printers' Ink* what data agencies usually require in planning an advertising campaign, the editor states, in part:

> In many cases the advertiser is unable to furnish all of the information wanted. On this account, of late years, it has become common for agencies to conduct extensive trade and

consumer investigations, sometimes costing thousands of dollars and taking months of time.

N. W. Ayer & Son, a very large advertising agency, makes the following statement in one of its advertisements:

Our Plans Department makes an analysis and test of every product we advertise. It thoroughly digests all information relative to its manufacture and distribution.

In this department we have unusually complete and reliable statistics for visualizing distribution of population and wealth in relation to distribution and selling of merchandise. Moreover, no trouble is considered too great to get additional facts for the intelligent building up of an advertising plan.

Joseph H. Finn, President of the Nichols-Finn Advertising Co., states in an editorial in the *Chicago Herald:*

Modern merchandising campaigns are often the result of months of preliminary work. The heads of the business, the sales manager, the advertising manager and the advertising agent give to these conferences the best that each has. The entire merchandising procedure is carefully laid out, the market is studied, the demand is analyzed. Accurate information is secured on per capita consumption: competition is weighed with full allowance for its strength; inquiry is made into the relative prosperity of different territories.

And finally, let me refer to the Mahin Advertising Data Book, which contains, as stated on its title page, "facts and statistics in condensed form for the man who has advertising and merchandising problems to solve." This book of 500 pages, consisting almost entirely of detailed statistics, summarizes the uses of statistics to the advertiser as follows:

Statistics can show the advertiser where to find the people he wants to reach.

Statistics can help the advertiser in selecting his advertising mediums.

Statistics can help the advertiser in testing to what extent he is actually reaching the people he is after.

Report on Consumer Demand and Retail Conditions. Most extensive in scope and detail, and of unique importance to the manufacturer, the retailer, credit man, banker, advertising, and sales manager is the second annual report on consumer demand, the data for which was secured and compiled under the direction of Mac Martin, Chairman of the Educational

Research Committee of the Associated Advertising Clubs of the World. The report was published in the January, 1916, issue of *Associated Advertising* and comprises a stupendous piece of statistical compilation and presentation. A few paragraphs showing the nature and scope of the investigation, will be of interest:

> The committee has not attempted to express opinions. It has sought only to gather facts and to classify and present them in a form which would make them of the most use to business men.
>
> To obtain this information we have gone to the retail dealers in the lines closest to the consuming public—department stores, groceries, drug, hardware, jewelry and clothing stores. We have also obtained reports of stock carried as compared with the same period last year. We have asked them how their collections stand, so you may know the tendencies of the average consumer in regard to prompt payment in the United States and Canada at the present time. We have asked these dealers to report in definite percentages the increase or decrease in the amount they are spending for their own advertising. Every deduction and every percentage has been triple checked. . . .
>
> Our able assistants here in Minneapolis have given night and day . . . to steady work in an effort to present this information fresh from the books of the dealers from the Atlantic to the Pacific, and from the Gulf to Hudson Bay, in the shortest possible time.

The tables, graphs, and maps that are a part of this report contain a wealth of statistical material of great value to all in any way interested in the marketing or merchandising of any commodity.

Uses of Graphs. In going over the material on which this paper is based, the writer was impressed with the extensive use that is being made of the graphic method of presenting facts. The business executive has neither the time nor the inclination to ponder over tables of figures in order to digest them properly. He would much rather have the facts presented to him in a more intelligible manner—in pictorial or graphic form. As C. C. Casey puts it in an article entitled "Graphic Sales Pictures That Analyze the Business" in *Printers' Ink*, January 20, 1916:

Sales and advertising statistics should be "read" before they get to the executive. They should not be *statistics* at all, but *pictures*. The tabulator should be taught to give the executive the *facts* which *he* ordinarily expects to get out of the figures himself.

Says W. H. Ingersoll, quoted in *Printers' Ink*, April 15, 1916:

Graphic charts may be devised for any character of data and show in visualized form important relationships which cannot be gotten in any other way, nor can so much information be gotten in such limited space by any other method.

The vital statistics of a business or a department, like the vital statistics of a nation or a government, may best be concentrated for preservation in the form of graphic charts.

Numerous other quotations could be given to show the significance of graphs to business executives. As for specific instances, the graphic method was used extensively in the investigations of the Commercial Research Division of the Curtis Publishing Co., and in the *Chicago Tribune's* Survey of the city of Chicago. The Definite Data Maps, described above, are graphs, pure and simple. The report on consumer demand also has a very large number of maps and graphs, and besides there is the suggestion that

Hundreds of other maps and charts can be compiled from these figures. . . . For example, the increase in population, the weather conditions, bank clearings, building permits, saving bank deposits, war orders—all these may be charted in areas and compared with consumer demand, to the benefit of those whose special lines indicate such additional charts.

Graphs are being used to plot territorial sales and advertising, to correlate advertising expenditures with sales results, to show increases or decreases in business, to compare the results of different departments of a business, to trace sales during various months of the year in order to locate seasonal tendencies, and to analyze other significant conditions of a business. The writer has even observed the use of graphs in advertisements to the consumer. For example, a recent advertisement contained a graph plotting the percentage increases in the prices of certain materials during 1914, 1915, and part of 1916.

A most interesting adaptation of the graphic method by an advertising agency is the Hanff-Metzger "Maplan," a merchandising blueprint. The "Maplan" presents, in graphic form, the interrelations of all the elements and efforts involved in the merchandising and advertising of a firm or product. An idea of the scope and detail of one of these blueprints can be had from the fact that they have been made as large as fourteen feet in length.

In concluding this paper, it is well to repeat that the writer set out to present a number of *actual instances* in which statistical data or methods have been and are being employed to help in the solution of advertising, marketing, and merchandising problems. In order to do this most effectively, it was considered best to *quote* those who were availing themselves of statistical aid.

After going through all the material, the writer was considerably surprised at the great extent to which statistics were contributing to advertising and merchandising efficiency, even though some firms were only unconsciously utilizing statistical methods. And yet, it is the writer's most earnest conviction that statistics can and should be consciously employed by more firms, and more extensively by many firms already taking some advantage of this aid in solving effectively and accurately their advertising and marketing problems.

REVIEWS AND NOTES.

Storage, Handling and Sale of Food in Philadelphia. By Janice S. Reed Lit.

Food Inspection Service in Philadelphia. By Bureau of Municipal Research.

The above two reports were published together by the Henry Phipps Institute of Philadelphia.

The report on the storage, handling, and sale of food contains the results of a very extensive and intensive investigation of conditions in Philadelphia, covering a wide field and including almost every variety of food dispensing store in the city.

One is not quite certain in reading this report whether it is intended for general propaganda or a scientific study of the subject. Should it be considered as a scientific study, it undoubtedly lacks the scientific evidence as to the value of certain food protecting measures and is completely devoid of chemical and bacteriological analyses which would show possibilities for contamination, stages of decay, and the effect that these conditions might have upon the consuming public. Considering the bulletin from the angle of a popular document, the first striking difficulty is encountered in the method of scoring and tabulation of the facts, which, while not complex in itself, is described in a manner that could hardly be understood by the lay mind without much effort.

On page 16, after presenting facts on the distribution by nationalities of store keepers, there is a statement regarding exhibits which seems to have no relation whatever to the preceding text. Here and there, there are slips of expression, such as "built stores" which are not defined in any part of the report.

In interpreting the figures contained in the tables, there is no effort made to fix upon the condition that would seem most striking and requiring the most concentrated effort towards improvement. In analyzing the scores, the discussion is so complex as to make it almost impossible for the non-statistical mind to follow the thought.

One is at a loss to understand the significance of such sentences as this: "Meat also is often similarly exposed and, worse still, offered for sale, side by side with live poultry." There are some reasons why live poultry should not be sold side by side with meat, but the reader not familiar with the technicalities of the subject is at a loss to understand why such objections should exist.

For the size of the report, the amount of tabular material is wholly out of proportion and the statistics are so complex as to require the most careful study on the part of the reader in order to derive any sort of conception as to their significance. Had the material been translated into a few small charts, showing the frequency of good and bad conditions in the various

stores, the bulk of the statistical data included in the report could have been reduced to the advantage of the reader.

A number of maps are appended which purport to show the distribution of various kinds of stores in the sections studied. It is with the utmost difficulty that any one can read the symbols inserted near the little circles indicating the various stores. It would have been very much to the advantage of the reader if some statement as to the actual number of the various kinds of stores had been placed on a map, instead of attempting to show them by symbols near the circles which show their location.

The whole report suffers from a lack of focussing of the information gathered and leaves the reader with no definite conception as to what the actual situation in Philadelphia is.

Had the method of presentation contained in the report on the food inspection system in Philadelphia been used in the report on the storage, handling, and sale of foods, the report would have been greatly improved and its value to the public at large vastly increased.

Regarding the section on food inspection service in Philadelphia, one is prompted to commend its clearness, and, as the departments of the city had carefully gone over the material, it is undoubtedly accurate as to facts.

In his introduction to this pamphlet, Dr. H. R. M. Landis speaks of *trichina spiralis*, which is found parasitic in hogs, and suggests the necessity for avoiding the consumption of hogs affected with this disease. We are wondering whether Dr. Landis is aware of the fact that the Bureau of Animal Industry of the United States has estimated that even a superficial inspection of all hogs slaughtered in this country with a view to eliminating those affected by the disease would run into the millions, and that even then the results would be questionable. The only alternative is a thorough cooking of the meat.

Dr. Landis also suggests that animals affected with tuberculosis be rejected for food purposes. Does Dr. Landis disagree with the United States Bureau of Animal Industry, which allows the use of such animals where the lesions are well-localized and the affected parts could be removed.

CAROL ARONOVICI,
Philadelphia.

BOARDS OF TRADE AND BUSINESS STATISTICS.

The yearbook of the Board of Trade of the City of Newark (N. J.) for 1916 contains an extensive "statistical summary of Newark," compiled under the direction of Secretary James M. Reilly. This feature of the annual report has served for many years to inform inquirers on the industrial and commercial resources of Greater Newark. It gives in short compass the essential facts of population, industry, and municipal and state government.

This organization has taken considerable interest in advancing the cause of industrial and commercial statistics. In 1915, it coöperated with the

Bureau of the Census in taking the manufactures census and proposes during the winter of 1916–1917 to devote one meeting to a consideration of statistics as an adjunct to business administration.

E. W. KOPF.

The Mathematical Theory of Probabilities and Its Application to Frequency Curves and Statistical Methods. By Arne Fisher. Volume I. Mathematical Probabilities and Homograde Statistics. New York: The Macmillan Company, 1915. Pp. xx+171.

Statisticians will welcome the appearance of Fisher's treatise because of the scarcity of such texts in the English language, and particularly because of the clearness and judgment with which the present book is written. They will await the appearance of the second volume with impatience; for it is in that volume that the more advanced development of statistical methods will be given. The present part deals almost entirely with the mathematics and the philosophy which underlie the theory of probability and which cannot be hastily put aside if a really fundamental knowledge of its applications to statistics is to be acquired.

The titles of the different chapters, with their initial page numbers, will indicate briefly the contents of the book:

I. Introduction: General Principles and Philosophical Aspects, p. 1. II. Historical and Bibliographical Notes, p. 11. III. The Mathematical Theory of Probabilities, p. 17. IV. The Addition and Multiplication Theorems in Probabilities, p. 26. V. Mathematical Expectation, p. 49. VI. Probability a Posteriori, p. 54. VII. The Law of Large Numbers, p. 82. VIII. Introductory Formulas from the Infinitesimal Calculus, p. 90. IX. Law of Large Numbers: Mathematical Deduction, p. 96. X. The Theory of Dispersion and the Criterions of Lexis and Charlier, p. 117. XI. Application to Games of Chance and Statistical Problems, p. 127. XII. Continuation of the Application of the Theory of Probabilities to Homograde Statistical Series, p. 146.

There has been so much discussion, if not controversy, concerning the foundation of the theory of probabilities, whether it should be upon an *a priori* or *a posteriori* basis that the author's careful discussion of the value and of the necessity of both bases is particularly welcome; he says in particular how careful one must be in the application of Bayes's Rule, and how a careless application of the Rule has been responsible for some of the distrust of the whole theory of *a posteriori* probability. Indeed it may well be said that the necessity for critical care in all statistical work is the impression which the reader gets most strongly from the text, as a quotation from the final section will show:

"A statistical research may be likened to the navigation of a difficult waterway, full of hidden rocks and skerries out of sight to the navigator. The amateur statistician, sailing the ocean in a blind and happy-go-lucky manner, often comes to grief on those rocks and suffers a total shipwreck.

The skillful navigator, the mathematically trained statistician, is always on the lookout for the sea marks. In the Lexian Ratio and the Charlier Coefficient of Disturbancy he recognizes a beacon light, often signalling 'Danger ahead.' He stops his engines. In case he does not possess the particular charts giving the exact location of the hidden reefs his prudence advises him to call a pilot to bring his ship safely into harbor. On the other hand, if he has reliable charts and knows his profession thoroughly he may venture forth and do his own piloting, by a study of the charts. It is to the study of such charts—*i. e.*, a special study of the higher statistical characterisitcs—that we shall turn our attention in the second part of this treatise. The reader who has followed us up to this point may perhaps feel discouraged by realizing how little he has gained in knowledge after having learned a mass of technical detail and formulas. We can quite appreciate and understand this feeling. So far, he has perhaps chiefly been impressed by the treacherous and misleading character of statistical mass phenomena, but to recognize a danger signal and thus avoid the pitfalls is one of the fundamental essentials in safe navigation in statistical research."

The typography of the book is excellent and the style also generally idiomatic, though occasionally there is evidence that the author wrote originally in Danish, and that in the translation an occasional slip has been made which will interest and not confuse the reader.

EDWIN BIDWELL WILSON.

Massachusetts Institute of Technology.

THE MEMORIAL VOLUME.

The delay in publishing the *Memorial Volume* of the American Statistical Association requires some explanation.

Prior to the outbreak of the Great War a number of articles on the History and Organization of Official Statistics in various countries had been received, but some of the most important essays were still missing. Those on Russian, German and Swedish Statistics have been finished *during the war.*

At the present time there are at hand and in page-proof articles on the official statistics of the following countries: Australia, Austria, Belgium, Canada, Denmark, Germany, Great Britain (including Ireland), Holland, Hungary, India, Norway, Russia, Sweden, and the United States.

Many difficulties have prevented the completion of the French, Italian, and Japanese studies. That a country so important statistically as well as in other respects as France, for instance, could not be omitted from our volume without seriously marring an important piece of work goes almost without saying. The alternative of printing these delayed articles in our regular QUARTERLY PUBLICATIONS did not appeal to the committee, and it has therefore been resolved to postpone publication until at least the promised study of French official statistics shall have been completed. And reason-

able assurance can now be given that this article will be finished within a few months as it has been possible to interest the French government in our plan. It is also confidently hoped that the delay will enable us to include an article on Japanese and probably one on Italian statistics.

We therefore reckon upon a volume in which practically all the important countries of the world will be represented through studies prepared for it by the foremost statisticians in each. Fortunately the delay does not age the material. It will be just as fresh and valuable as if it had been issued at the time first projected and worthy not only of our Association but of the science of statistics. It has required a large amount of labor, patience, and persistence to bring the volume up to its present state of completion. To forego the ideal set at the time the collection of the material was first undertaken merely for the sake of gaining a few months of time would certainly tend to spoil what we believe now promises to be a reasonably perfect piece of work.

As soon as practicable, members of the Association will be notified of the probable date of publication and of the conditions upon which it may be obtained.

JOHN KOREN,
For the Committee in Charge.

Publications of the American Statistical Association.

The New Series of the Association, issued quarterly, will be sent to members of the Association on payment of the annual dues of two dollars. The subscription price is also two dollars per annum. Separate copies can also be purchased upon remittance of the advertised prices.

The following list of titles includes only the most important papers published in the several issues. There is in addition a considerable amount of miscellaneous material.

VOL. I. 1888-1889. Nos. 1-8. Pp. 492. PRICE $4.00.

No. 1. Statistics of Water Power Employed in Manufacturing in the United States. GEORGE F. SWAIN. 75 cents.

Nos. 2, 3. Park Areas and Open-Air Spaces in American Cities. E. R. L. GOULD.

Key to the Publications of the United States Census, 1790-1887; with Occasional References to Other Statistical Works. EDWARD CLARK LUNT. $1.00.

No. 4. Life Insurance in the United States. WALTER C. WRIGHT. $1.00.

No. 5. Notes on the Statistical Determination of the Causes of Poverty. AMOS G. WARNER. REMARKS. SAMUEL W. DIKE.

Statistics of Divorce in the United States and Europe. SAMUEL W. DIKE. 50 cents.

No. 6. American Railroad Statistics. ARTHUR T. HADLEY.

Statistics of Municipal Finance. HENRY B. GARDNER. 75 cents.

No. 7. Prison Statistics of the United States for 1888. ROLAND P. FALKNER. 50 cents.

No. 8. Finance Statistics of the American Commonwealths. EDWIN R. A. SELIGMAN.

Divorce in France. BENJAMIN F. KELLER.

Relief of the Poor in Germany. A. G. WARNER. $1.00.

VOL. II. 1890-1891. Nos. 9-16. Pp. 470. PRICE $4.00.

No. 9. Mortgage Statistics. GEORGE K. HOLMES. 50 cents.

No. 10. The Study of Statistics in Italian Universities. CARROLL D. WRIGHT.

Statistics of Private Corporations. ROLAND P. FALKNER. 50 cents.

Nos. 11, 12. Statistics of the Colored Race in the United States. FRANCIS A. WALKER.

How to Make Statistics Popular. CHARLES F. PIDGIN.

Retail Prices in Boston and Vicinity. WALTER F. COOK. $1.00.

No. 13. The Growth of Cities in Massachusetts. HORACE G. WADLIN.

Rate of Natural Increase of Population in United States. HERMAN HOLLERITH.

The First Census of Massachusetts. SAMUEL A. GREEN.

The Commercial Death Rate. ALBERT C. STEVENS. $1.00.

No. 14. A Basis for Statistics of Cost of Production. CARROLL D. WRIGHT.

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